THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXXIII.—*On the Tides at Key West, Florida, from observations made in connexion with the United States Coast Survey;* by A. D. BACHE, *Superintendent.*—Communicated by authority of the Treasury Department; revised from the Proceedings of the American Association for the Advancement of Science. (With six Plates.)

HOURLY observations of the tides were made at Fort Taylor, Key West, from the 1st of June, 1851, to the 31st of May, 1852, by Mr. J. W. Goss, of the Coast Survey and assistants. The tides ebb and flow twice in the twenty-four hours, but the diurnal inequality in height is relatively large, amounting at a mean to 0·55 foot, and reaching, in extreme cases, 0·83 foot.* The mean rise and fall of the tide being about 1·4 foot, a knowledge of the laws of the diurnal inequality by which successive high or low waters may differ is very important. The corrected establishment of Key West is 9h. 22m. The curves of Plates 1, 1 bis, 1 tris, 2, 3, 4, and 5, show the normal character of the tides at the maximum and zero of the moon's declination at the syzigies and quadratures, and at a mean of declination and six hours of the moon's age. There being two tides in the lunar day, the observations admit of discussion by the ordinary methods, while the large diurnal inequality in height of high water renders it desirable to pursue the mode which I have applied to the tides at Cat

* Throughout this paper the whole difference of the A. M. and P. M. tides is taken as the diurnal inequality.

Island (Louisiana), and Fort Morgan (Alabama.) The reductions by the ordinary methods thus become the tests of those by the other mode. The former were made under my immediate direction by Lieut. Richard Wainwright, U.S.N., and Mr. M. H. Ober, U. S. Coast Survey, and the latter by Mr. W. W. Gordon, assisted by Messrs. Mitchell, Homans, and others, of the Coast Survey.

The *half-monthly inequality* in time and height as deduced by the usual method is shown in the following Table No. 1, in which the first column contains the moon's age, the second the mean lunitidal interval corresponding, and the fifth the height.

TABLE No. 1.

Half-monthly inequality of tides at Key West from one year's observations.

Moon's age. 1.	Interval. O. 2.	Interval. T. 3.	Interval. O—T. 4.	Height. O. 5.	Height. T. 6.	Height. O—T. 7.
h. m.	h. m.	h. m.	m.	feet.	feet.	feet.
0 30	9 21	9 21	00	6·34	6·34	0·00
1 30	9 05	9 07	02	6·31	6·32	·01
2 30	8 51	8 54	03	6·25	6·26	·01
3 30	8 47	8 46	01	6·17	6·16	·01
4 30	8 50	8 55	05	6·08	6·06	·02
5 30	8 54	8 58	04	6·00	5·97	·03
6 30	9 22	9 25	03	5·94	5·94	·00
7 30	9 52	9 49	03	6·00	5·98	·02
8 30	9 59	10 00	01	6·02	6·08	·06
9 30	9 59	9 58	01	6·12	6·18	·06
10 30	9 53	9 58	05	6·22	6·27	·05
11 30	9 35	9 35	00	6·30	6·33	·03
	9 22					

The mean interval for this table is 9h. 22m., corresponding to the epoch of the moon's age of 24 minutes, showing that the transit E (of Mr. Lubbock's notation) and not F should be used in the reduction for theoretical purposes.

The comparison between the results of observation and those from the formula for the half-monthly inequality is shown in the fourth and seventh columns, the fourth referring to the interval and the seventh to the height. The difference in the mean is inappreciable, and, at a maximum, is but five minutes of interval, and six hundredths of a foot of height.

A graphic comparison is made on Plate 2. The value of the constant (A) of the formula for the interval, $\tan 2\psi = \frac{(A)\sin 2\varphi}{1+(A)\cos 2\varphi}$ is 0·325, and of E in the formula for the height $h = D + E[(A)\cos(2\psi - 2\varphi) + \cos 2\psi]$ is 0·620.

The values of the *diurnal inequality* of high and low water, both in time and height, were obtained by comparing the mean value of the interval and height for the first and second six months, with the individual values; they followed closely the law of change with the moon's declination. The inequality in height of high water at a mean is to that of low water as 79 to 61.

As the observations were only made hourly, and the inequality in the interval of high water is small, the minute changes from day to day could not be expected to show themselves. The inequalities were grouped according to the different declinations of the moon into fourteen periods, and the approximate formula, given by Mr. Lubbock, for the variation from the mean, was applied. The agreement with theory, as shown in the annexed table, is very close; G was taken as 1·15.

TABLE No. 2.

Comparison of the diurnal inequality of high water at Key West, with the formula $d\psi = \frac{G \tan \delta'}{1+(A)\cos 2\varphi}$.

Moon's declination.	Diurnal inequality.		Difference.
	Observed.	Computed.	
° ′	Minutes.	Minutes.	Minutes.
3 55	13	15	— 02
7 15	25	29	— 04
11 30	48	47	01
15 45	61	64	— 03
18 55	74	78	— 04
20 55	88	87	01
21 30	100	91	09
21 55	95	92	03
20 15	84	85	— 01
17 30	83	72	11
13 55	52	56	— 04
9 15	37	38	— 01
5 15	25	21	04
2 55	07	11	— 04
			— 23
			+ 29
			52

The inequalities of time of high water were also arranged according to the moon's age, but the agreement of the observation with the formula is not as close as in the former case, as must be the case from the small number of observations, and the variation of the inequality following chiefly the law of the declination. The law of change is still evident in the grouping, and the plus and minus quantities balance nearly.

The discussion of the diurnal inequality in height will be resumed in referring to the diurnal wave, after noticing the decomposition of the curve of observation into a semi-diurnal and diurnal curve.

Decomposition of the curves of observation.

As in the discussion presented for the Cat island tides, the curves of observation at Key West were decomposed into two—one representing the semi-diurnal and the other the diurnal tide. The interval (E), which was in the former case assumed to be constant, was here treated as variable. The observed ordinates being referred to the mean of high and low water of the day as

a zero, were tabulated, and the maximum ordinates S and D of the semi-diurnal and diurnal curves of sines found, taking (E) generally at its mean value. From these the ordinates of each curve for the several hours were obtained, and thence the ordinates of the compound curves. These were compared with observation, and E was next made to vary until the value was found, which gave the sum of the differences of computation and observation, without regard to sign, the smallest.

It was next intended, treating this as a first approximation, to take a different zero-point for the semi-diurnal curve, but the labor necessary has prevented this idea from being followed up thus far, and the agreement of the computed and observed curves is quite satisfactory in the cases in which E is not varying too rapidly for safe deductions. The labor and uncertainty of deducing E from the observations in the manner just referred to is very considerable, and, after one full comparison made in this way, the values will be deduced from theory, and applied to the curves.

The approximate compound curve was next projected on a diagram of suitable scale, and the outline cut from the paper so as to apply it to the curve of observation, and thus to find its best position in reference to that curve, and to determine the times of high water. The work referred to in the paragraphs preceding the last is mechanical, but this latter requires much judgment, and has been executed by Mr. W. W. Gordon. Supposing that some discrepancies observed might result from a sort of personal equation in making these comparisons, a second person was engaged to repeat them for verification, and the result showed that the comparison could be depended upon in individual cases to within about five minutes in time in the position of the maximum ordinates.

Semi-diurnal Tides.

The times of high water from the semi-diurnal curves being taken from the diagrams, are subject to an error, which Mr. Gordon estimates as from four to five minutes. This, however, does not appear in the final results, which agree as well with theory as those for the heights, not subject to any such error of estimate.

The lunitidal intervals and heights found were tabulated according to the moon's age, as in the following tables, which contain the result for the first and second six months of the year and for the whole year. The fourth and seventh columns contain, respectively, the differences in the interval and height drawn from the curves, and from the formula for the half-monthly inequality referred to in the previous part of this paper:

TABLE No. 3.—*First six months.*

Moon's age.	Interval.			Height.		
	O.	C.	Difference. O—C.	O.	C.	Difference. O—C.
H. M.	H. M.	H. M.	M.	feet.	feet.	feet.
0 30	8 53	8 54	1	0·75	0·75	0·00
1 30	8 38	8 42	4	·73	·72	·01
2 30	8 29	8 30	1	·64	·66	·02
3 30	8 24	8 24	0	·60	·58	·02
4 30	8 28	8 27	1	·48	·49	·01
5 30	8 42	8 40	2	·45	·43	·02
6 30	9 06	9 03	3	·42	·42	·00
7 30	9 23	9 23	0	·44	·46	·02
8 30	9 31	9 30	1	·53	·54	·01
9 30	9 28	9 28	0	·61	·62	·01
10 30	9 20	9 19	1	·68	·69	·01
11 30	9 09	9 07	2	·75	·74	·01
	8 57					

TABLE No. 4.—*Second six months.*

Moon's age.	Interval.			Height.		
	O.	C.	O—C.	O.	C.	O—C.
H. M.	H. M.	H. M.	M.	feet.	feet.	feet.
0 30	8 53	8 52	1	0·78	0·77	0·01
1 30	8 42	8 39	3	·72	·75	·03
2 30	8 27	8 28	1	·69	·68	·01
3 30	8 22	8 21	1	·59	·59	·00
4 30	8 22	8 23	1	·49	·49	·00
5 30	8 34	8 38	4	·46	·42	·04
6 30	9 04	9 03	1	·40	·40	·00
7 30	9 22	9 23	1	·44	·45	·01
8 30	9 31	9 31	0	·53	·54	·01
9 30	9 32	9 28	4	·62	·64	·02
10 30	9 20	9 19	1	·69	·72	·03
11 30	9 04	9 06	2	·71	·77	·06
	8 56					

TABLE No. 5.—*The whole year.*

Moon's age.	Interval.			Height.		
	O.	C.	O—C.	O.	C.	O—C.
H. M.	H. M.	H. M.	M.	feet.	feet.	feet.
0 30	8 53	8 53	0	0·76	0·76	0·00
1 30	8 40	8 40	0	·73	·74	·01
2 30	8 28	8 29	1	·67	·67	·00
3 30	8 22	8 22	0	·59	·59	·00
4 30	8 25	8 25	0	·49	·50	·01
5 30	8 38	8 39	1	·45	·43	·02
6 30	9 05	9 03	2	·41	·41	·00
7 30	9 22	9 23	1	·45	·46	·01
8 30	9 31	9 31	0	·53	·54	·01
9 30	9 30	9 28	2	·62	·63	·01
10 30	9 20	9 19	1	·69	·71	·02
11 30	9 06	9 07	1	·73	·75	·02
	8 57					

Curves showing the result of these comparisons are given in Plate 2. The greatest difference for the whole year between the two sets of results is but one minute of time for the interval, and ·02 foot in height.

The results are in apparent time, the substitution of which for mean time was, however, appreciable in but a slight degree.

There are several small corrections suggested by the hypothesis which has been adopted, but the small value of the residuals renders the following of them up unnecessary. To the last computations we have reached no greater accuracy than is presented by these residuals, and could not safely base any conclusions on less quantities.

The ordinates used in the heights are the maximum ordinates of the component curves, and not those of high water of the compound curve; but it is easily shown that when the value of (E,) when most nearly constant, is, as at Key West, between about nine and nine a half hours, this difference is inappreciable.

The solar day having been used in this decomposition instead of the lunar, the curves are at a mean twenty-five minutes behind their true place, and the mean lunitidal interval differs twenty-five minutes from the truth; adding this quantity, it agrees, as it should do, with the former determination.

For the reason just assigned, these numbers would require correction before using them to determine the constants. This, when made, gives the result as before stated.

Diurnal tides.

The maximum ordinates found for the diurnal tides from the decomposition of the curves of observation were grouped according to the declinations of the moon, by magnitude without regard to sign, as shown in the first and second column of Table No. 5.

The maximum ordinates may, in this case, be reduced to high water ordinates by a very simple process, and thus a comparison be established between this mode of reduction and the ordinary one. For (E)=9h. 30m., the high water ordinate is 0·79, the maximum, provided, as in the case at Key West, the time of high water may be taken as that of the semi-diurnal wave.

The following table shows the moon's declination, the corresponding mean maximum ordinate, twice the high water ordinate deduced from this, (which is the diurnal inequality from our mode of reduction,) the diurnal inequality as usually obtained, and the difference.

TABLE No. 6.

Sine twice moon's declination.	Maximum ordinate.	Twice high water ordinate, (C.)	Diurnal inequality, (C').	Difference, (C'—C).
	feet.	feet.	feet.	
11	0·12	0·20	0·19	—·01
21	·17	·27	·28	·01
35	·28	·44	·44	·00
48	·38	·59	·60	·01
59	·46	·71	·70	—·01
66	·51	·80	·79	—·01
69	·54	·84	·83	—·01
Mean		·55	·55	

The results are represented in Plate No. 3.

The statement made above in relation to the high water ordinates is not true for those of low water, as the consideration of the formula $y = C.\cos 2t + D\cos(t - E)$ will show, making $E > 9$ hours. The reverse is the case if $E < 9$ hours, the statement applying then to the inequality of low water and not of high. At Key West, while the high water inequality in height is thus readily found from the maximum ordinate, the low water presents a less accordant result; while at Cedar Keys just the reverse occurs, as should be the case.

It is plain, also, that changes in the coefficients C, D, and in E, will cause the inequalities in times and heights to vary, as well as those of high and low water, losing all correspondence with each other, as is also well shown in the annexed diagram. Mr. Gordon suggests that in the value of (E) will be found the full explanation of the peculiarities of the Petropaulofsk tides described by the Rev. Mr. Whewell.

In diagram No. 1, Plate No. 5, E is assumed 9 hours and S = D, and the inequality of high and low water in interval and height correspond to each other. The same is the case for E = 15 hours. In No. 2, E is 12 hours, and S = D. The inequality in interval of high water is 0h., of low water 4h., when that in height of high water is 2 feet, and of low water 0 feet. For E, 18 hours and S = D, these inequalities would be reversed, that of interval of high water being 4h., and of low water 0h., while for height the inequality of high water is 0 feet, and of low water 2 feet.

Using the high water ordinates, determined as before stated, instead of the diurnal inequality in height, from which it has been shown not to differ sensibly, the numbers were compared with those of Mr. Lubbock's formula:

$$dh = B\,[(A)\sin 2\delta\cos(\psi - \varphi) + \sin 2\delta\cos\psi];$$

Neglecting the variations of $\cos(\psi - \varphi)$, $\cos\psi$, the coefficients B and (A) B were found by least squares for the separate six months and for the year, agreeing sensibly in the partial and total determinations. From two years' results, B = 0·56 and (A) B = 0·16. The value of (A) thus obtained is, as it should be, the same as deduced from the half-monthly inequality.

The sum of the squares of the difference of the numbers from the formula, and from the computed high water ordinates, is for the year but 0·0087 foot; corrected for the moon's parallax, but 0·0078 foot.

The individual results are given in the annexed table, in which the first column contains the moon's age, the second the difference between the computed high water ordinates and the corresponding quantities from the formula for the variations of the

diurnal inequality in height, corrected for parallax, and the third the same, as uncorrected for parallax.

TABLE No. 7.

Moon's age.	Diurnal inequality height; observation—theory.		Moon's age.	Diurnal inequality height; observation—theory.	
	Corrected.	Uncorrected.		Corrected.	Uncorrected.
H. M.			H. M.		
0 30	005	010	6 30	−080	−085
1 30	005	005	7 30	−090	−090
2 30	−035	−030	8 30	−065	−065
3 30	−035	−035	9 30	−020	−020
4 30	−075	−080	10 30	−030	−030
5 30	−070	−070	11 30	+005	010

The residuals are very small, but follow the law of the half-monthly inequality, as was found, also, from the corresponding results of the Cat Island observations.

The discussion of the value of E, which is in progress, I hope to present at a future meeting of the Association.

Changes of mean level.

The mean level of the water at Key West was seen from the observations to undergo remarkable changes from one period of the year to another. A comparison of the reductions for the first and second six months shows that the high water of neap tides of the first period rises actually to a higher level than the high water of spring tides of the second. The mean level of the high water for the first six months exceeds that for the second by 0·48 foot. The form of the half-monthly inequality is perfectly regular in each six months. The guage had remained undisturbed; and in seeking for the explanation, it was observed that the mean level of the water varied very materially in the two periods, there being a change which appeared to go through its variations in the course of the year.

The annexed table shows the heights of high water at the several ages of the moon in the first and second six months, referred to the same zero.

TABLE No. 8.

Moon's age.	Height of high water.	
	First six months.	Second six months
H. M.	feet.	feet.
0 30	6·63	6·05
1 30	·59	·04
2 30	·48	·02
3 30	·38	5·97
4 30	·31	·86
5 30	·26	·75
6 30	·17	·72
7 30	·28	·72
8 30	·26	·79
9 30	·34	·90
10 30	·43	6·01
11 30	·54	·06
	6·39	5·91

I hardly supposed that the numbers representing these changes of level would furnish evidence of the two interesting tides of long period pointed out by Mr. Airy, (Tides and Waves, Encyc. Metrop., p. 355;) they do so, however, and in the case of the moon's action, where the number of averages which can be brought to bear upon a single result is considerable, and the observations run through various parts of the year, the results bear carrying to numerical comparison with the formula. These tides, as far as I am aware, have not been developed from observation, though certain general analogies pointed to their existence. Dividing the numbers showing the daily level of the water into groups of nearly fourteen days, each corresponding to the moon's declination from the maximum to the maximum again, and taking the mean of each set corresponding to the same declination, we obtain a series which is the average of twenty-six numbers in which the irregularities of the depressing and elevating action of the winds will be eliminated, and in which the sun's action will be nearly the same. This series presents a tolerable regularity increasing to a maximum at zero of declination, as shown in Plate No. 6, curve No. 1.

Taking the mean level of the water for each fourteen days, and dividing the results into two groups corresponding to the same declination of the sun, north and south, we have a series of numbers which, though less regular than the others, also rise towards the zero of declination, as shown in Plate 6, curve No. 2.

The results of the first series of computations bear very well a comparison with the formula given by Mr. Airy:

$$(1{\cdot}34\times\sin^2\mu+0{\cdot}61\times\sin^2\sigma)\,(\cos 2\lambda+c,)$$

in which μ and σ are the declinations of the moon and sun respectively, and λ is the latitude of the place, requiring $C=0$. Those of the second present greater discrepancies and require $C=\frac{1}{3}$, contradicting the former. Though the weight of authority is that in favor of the criterion of the wave theory $C=0$, the result is inconclusive. In either case the whole number involved is less than the tenth of a foot, the theoretical lunar tide being 0·095, and the measured 0·098, while the theoretical solar tide for $C=0$ is 0·046, and the measured is 0·077.

It may be necessary to remark that for places of low latitudes the increase of numbers in the formula corresponds to a fall of the tides.

The regularity of the winds of this region, the trade winds, taken in connexion with the form of the harbor, point also to their action as a source of explanation of this change of level. The meteorological tables kept while the tidal observations were made, furnish means for a complete discussion, which is in progress. I may remark, now, that winds tending to elevate the water in the harbor prevail for six months, from March to August inclusive, and those tending to depress it for the other six months, from

September to February inclusive. The subject is one in which it is difficult to come to numerical results, because the variations in the force of the wind and the duration both enter into the effect, and distant action sometimes causes local effects. The whole rise and fall is nearly three-quarters of a foot.

The mean level of the water deduced from the mean of high and low water in each month is shown in the annexed table.

TABLE No. 9.

Month.	Height in feet.	Month.	Height in feet.
June, - - -	5·60	December, - - -	5·31
July, - - -	·78	January, - - -	·11
August, - - -	·63	February, - - -	·15
September, - -	·93	March, - - -	·26
October, - - -	·90	April, - - - -	·26
November, - - -	·73	May, - - - -	·32
	5·76		5·24

Art. XXXIV.—*On the Geographical Distribution of Crustacea;* by James D. Dana.*

In volume xvi, of this Journal, the author presented a chart of oceanic isothermal (or rather isocrymal) lines, for the illustration of marine zoological geography, prepared more especially with reference to the geographical distribution of Crustacea, and taken from his Report on the Crustacea of the Exploring Expedition around the world under Capt. Wilkes. The following is a brief abstract of the remainder of the Chapter on the Distribution of Crustacea; the Tables which occupy near 30 pages are omitted besides other details.

The lines on the chart, it may be here repeated, are lines of equal winter (or coldest month) temperature for the water, the "cold" lines being adopted because the distribution of species away from the Tropics is limited by cold temperature. The temperatures corresponding to the lines are 74°, 68° (limiting temperature of coral reefs), 62°, 56°, 50°, 44°, 35° F. Between the lines of 68° F. north and south of the equator lies the *Torrid Zone* of oceanic water temperature; from the line of 68° to that of 35°, the *Temperate Zone;* beyond the line of 35°, the *Frigid Zone.* These Zones are divided by the lines into Regions or Sub-zones as follows.

I. TORRID ZONE.	1. Torrid Region or Sub-zone,		74° and above.
	2. Subtorrid	"	68° to 74°
II. TEMPERATE ZONE,	1. Warm Temperate	"	62° to 68°
	2. Temperate	"	56° to 62°
	3. Subtemperate	"	50° to 56°
	4. Cold Temperate	"	44° to 50°
	5. Subfrigid	"	35° to 44°
III. FRIGID ZONE.			

* From the Author's Report on Crustacea, (2 vols. 4to, 680 and 1620 pages).

The reader is referred to the former paper and map for other details, where the Zoological Provinces in these zones are laid down, and explained.

The Tables are in two series. The first contains for each genus of Crustacea the number of species *according to present knowledge* in each temperature Region or Sub-zone.* The second, the number for each genus in each *Geographical Province.*

We proceed with a summary of the results presented in the first series of the Tables.

I. BRACHYURA.

	a. Torrid.	*b.* Sub-torrid.	Total of Torrid zone.	*c.* Warm Temperate.	*d.* Temp'ate.	*e.* Sub-temperate.	*f.* Cold Temperate.	*g.* Sub-frigid.	Total of temperate zone.	*h.* Frigid.
Maioidea, - - - -	82	57	122	35	27	21	16	14	92	3 (2)
Cancroidea - - - -	157	112	229	22	25	23	25	8	69	3 (3)
Grapsoidea, - - - -	72	88	131	21	14	27	10	9	63	
Leucosoidea, - - -	35	33	48	11	8	5	3	2	24	
Corystoidea, - - -	2	3	5	2	4	2	6	6	16	1 ?
	348	293	555	91	78	78	60	39	264	

This table contains the number of species of the orders of Brachyura, according to present knowledge, in each Region and Zone.

The following general facts or conclusions may be deduced from the Tables of the Brachyura.

I. The line of division, separating the Torrid and Temperate zones of ocean temperature, following the isocryme of 68° or the outer limit of coral reef seas, marks a grand boundary in organic life, well exemplified in Crustacean species. Out of the five hundred and thirty-five species of the Torrid and Subtorrid Regions (the Torrid zone,) there are over one hundred now known to be common to the two. But of the two hundred and sixty-four in the Temperate Regions, only thirty-four occur in the Torrid zone. A large number of genera, containing more than a single known species, are confined wholly to the Torrid zone: such are Micippa (5 species), Menæthius (9), Huenia (4), Parthenope (3), Atergatis (17), Carpilius (13), all the Chlorodinæ, including forty-nine species, nearly all the Eriphinæ, including eighteen species, Charybdis (15). At the same time, the species of the Torrid and Subtorrid Regions are in many cases equally numerous. Of species of Charybdis, eleven species occur in each of these Regions; of the Carpilii, eleven are reported from the Subtorrid and but five from the Torrid; of the Menæthii, five are found in the Torrid Region, and six in the Subtorrid, only two being common to both. These proportions may be much varied by future in-

* Since the ocean's waters decrease in temperature as we descend in depth, there will be some error in the tables from the cold water species thus passing into regions nearer the equator. But this error will diminish the number of species regarded as peculiar to the colder regions, and if eliminated, the following conclusions would be still more strongly sustained.

vestigations. Still it cannot fail to be evident from a survey of the tables, that the line between the Torrid and Temperate zones is a natural zoological limit.

II. The Torrid species of Brachyura (Torrid and Subtorrid Regions) greatly preponderate over those of the Temperate zone, the proportion being above two to one. This fact is the subject of remarks by Edwards, but with different conclusions from those which we would deduce.

III. The Frigid zone, as far as known, includes *one* species peculiar to it, the *Chionœcetes opilio*. And *Stenorhynchus phalangium*, *Hyas araneus*, *Portunus pusillus*, *Carcinus mœnas*, and *Cancer pagurus*, are all that are known to extend into it from the Temperate zone. Perhaps the *Cancer chirogonus* from Kamtschatka (*Telmessus chirogonus* of White) should be added. This may be in part evidence of the little exploration hitherto made in the Frigid Seas. Yet, after the investigations of Beechey, Fabricius, Kröyer, Rathke, and others, we may be assured that the number of species is exceedingly small.

IV. Within the Temperate zone, the species are most numerous in the Warm Temperate, Temperate, and Subtemperate Regions; beyond this, the number diminishes, being a *quarter less* in the Cold Temperate than in the Subtemperate, and *half less* in the Subfrigid. Moreover, in the last-mentioned region, seventeen out of the thirty-nine species, or nearly one-half, occur in warmer temperate latitudes, only twenty species being confined to the Region.

V. In the Torrid zone, the species of the torrid region, amounting to three hundred and forty-eight, exceed in number those of the Subtorrid by only forty-five, although the Subtorrid region is not one-third as great, both as to surface and extent of coast line.

VI. Passing now from these general considerations respecting the Brachyura as a class to the several orders, we may look at their ratios among these orders and their subdivisions, for the several regions, in order to discover what is the relation of the species to temperature, and whether the cold or warm-water species are the higher or lower in grade, or whether the torrid or the temperate zone can claim species of the highest perfection or magnitude among the Brachyura.

The following table gives the ratio which the number of species of the several orders in the Temperate and Frigid zones, bears to that of the Torrid zone.

1. Maioidea,	1 : 1·3
2. Cancroidea,	1 : 3·3
3. Grapsoidea,	1 : 2·1
4. Leucosoidea,	1 : 2·0
5. Corystoidea,	1 : 0·3

It hence appears that the Maioidea and Corystoidea are proportionally much more abundant in the colder seas than the Cancroidea, Grapsoidea, or Leucosoidea.

If we examine into the subdivisions of the Maioidea and Cancroidea, we shall find the difference between the two groups in distribution more strikingly brought out. We shall find, moreover, that both groups may be divided into a warm-water and cold-water section, as below.

I. MAIOIDEA.

1. COLD WATER OR TEMPERATE ZONE SECTION.

	Torrid species.	Temperate species.
1. Inachidæ,	1	10
2. Maiidæ, subfamilies, *Libininæ, Maiinæ, Pisinæ, Othoninæ,*	15	35
3. Eurypodidæ,	0	7
4. Leptopodidæ,	1	8
	17	60

2. WARM WATER OR TORRID ZONE SECTION.

	Torrid.	Temperate.
1. Maiidæ, subfamilies *Micippinæ, Chorininæ, Pyrinæ,*	16	3
2. Mithracidæ,	11	6
3. Tychidæ,	4	0
4. Periceridæ,	43	14
5. Parthenopinea,	28	8
6. Oncininea,	2	0
	104	31

II. CANCROIDEA.

1. TEMPERATE ZONE SECTION.

	Torrid.	Temperate.
Cancridæ,	0	11
Platyonychidæ,	2	7
Portunidæ, subfamily *Portuninæ,*	0	15
Cyclinea,	0	1
	2	34

2. TORRID ZONE SECTION.

	Torrid.	Temperate.
Xanthidæ,	129	16
Eriphidæ,	44	12
Portunidæ, excluding the *Portuninæ,*	52	7
Podophthalmidæ,	2	0
	227	35

We have here two singular facts brought out.

First, that the cold-water section of the Cancroidea embraces those species that approach most nearly to the Corystoidea, and which we have elsewhere shown to be the *lowest* in grade of the Cancrinea. All have the lax character of the outer maxillipeds, which is a mark of degradation in the Corystoids; and the Cyclinea are still nearer that group. Many of the species moreover have the hind legs a swimming pair, another mark of degradation. The Corystoidea, as before shown, are two-thirds cold-water species.

Second, that the cold-water section of the Maioidea contains the species that are *highest* in grade, and largest in size. It is headed by the Macrocheira of Northern Japan, the king of all crabs, whose body is seventeen inches in length and a foot broad;

with extended legs, it sometimes covers a breadth of eleven feet, and the anterior legs or arms are *four feet* long!* The species of the other genera are mostly among the larger of the Maioids, and have no mark of inferiority. Such are the species of ***Maia***, ***Pisa***, ***Libinia***, ***Eurypodius***, etc.

But among the species of the warmer section, we find the Oncininea and Parthenopinea, both manifestly inferior in grade, the former approaching even the Anomoura, and the latter forming the passage of the Maioids to the Cancroids, as has been explained. We observe also the Periceridæ and the Tychidæ, all very small species, excepting a few Periceræ: the Menæthii, Tiariniæ, and Acanthonyces, are examples of the group. In addition, there are the Mithracidæ, which although attaining a large size show their inferiority in their shorter epistome, shorter body, which is sometimes even transverse, and their spoon-shaped fingers. In the last character, the Chlorodinæ among the Cancroids, similarly show their inferiority to the Xanthidæ. That this kind of finger is such a mark of inferiority is apparent from its diminishing in many species as the adult size of the animal is attained, the tendency being towards producing the acuminated finger found in the highest grades.

We are hence sustained in the conclusion that the Maioids of the Temperate zone are generally those that are highest in grade. It also shows the congeniality of cold waters to the Maioids, that the only Brachyuran peculiar to the Frigid zone is of this group. We refer to the Chionœcetes opilio.

VII. The Brachyura, therefore, although most numerous in the Torrid zone, do not reach in this zone their highest perfection. On the contrary, the Temperate zone or colder waters are the habitat of the highest species. Hence, as the Maioidea stand first among all Crustacea, the highest development of the class Crustacea takes place, not in the Torrid zone, the most profuse in life, but beyond the tropics and coral-reef seas, in the middle Temperate Regions.†

VIII. The prevalence also of the inferior Corystoids in the colder waters does not invalidate this conclusion, as the fact respecting the Maioids is wholly an independent one; for these last, by attaining their highest perfection in these coldest waters, determine the principle as regards themselves, the highest grade of Crustacea. Lower grades occur also in the colder waters, and the laws governing their distribution demand separate study and consideration.

IX. Passing a step below the Maioids, we come to the Cancroids, and these, with the exception of the lower Corystoid species, and only *one-eighth* of the rest, are Torrid zone species.

* De Haan's Fauna Japon., Crust. p. 101.

† On the coasts of Britain, the Cancroids (excluding the swimming species,) are only half as numerous as the Maioids.

X. If the Torrid zone is the proper region for the full development of the Cancroid type, and its heat is needed for this end, it is natural that species of Cancroids like the *Portuninæ*, *Platyonychidæ*, and *Cancridæ*, found in the less genial waters of the Temperate zone, should bear some mark of inferiority;—and it is a fact that they have such marks in their structure. This inferiority is not seen in their smaller size,—for a larger size under certain conditions, may equally evince a lower grade,—but in the inferior concentration of the life-system, exhibited either in the lax outer maxillipeds, the elongation of the antennæ and abdomen, or in the smaller size or swimming character of the posterior legs.

For a like reason also, the species of Corystoidea, a grade still lower, naturally occur in the cold and ungenial region they frequent.

We hence perceive, that the degradation among the Maioids takes place when the species become warm-water species, and the degradation among the Cancroids, in the reverse manner, when the species become cold-water species; for the reason that the colder waters are the proper habitat for the Maioid type, and the warmer for the Cancroid type.

XI. In the tables of the Maioidea and Cancroidea of the Temperate and Torrid zones, page 317, the species are included by families and subfamiles, and consequently the peculiarities of the genera are not shown. In the families or subfamilies referred to the cold-water section, there is only one warm-water genus, viz., *Doclea*, of the subfamily *Libininæ;* it contains four Torrid and one Temperate zone species.

Among those referred to the warm-water section, there are the following cold-water genera:—

		Species in Torrid zone.	Species in Temperate zone.
Parthenopinea, genus	Eurynome, ...	0	2
" "	Eurynolambrus, . . .	0	1
Xanthidæ, "	Paraxanthus, ...	0	2
Ozinæ, "	Ozius, ...	2	3

The species of Cancrinea of the Torrid zone section, which reach farthest into the Temperate zone, are those of the following genera:—*Xantho*, which has eight Temperate zone species out of twenty-eight in all; *Panopeus*, which in the same way has four out of ten; *Pilumnus*, which has seven out of twenty-two; and *Lupa*, which has four out of ten. The cold Temperate Region is the highest for each of these genera, excepting Lupa and Pilumnus, a species of each of these latter genera extending just within the limits of the Subfrigid Region, on the coast of Massachusetts.

XII. The Grapsoidea, if divided between the Torrid zone and Temperate zone, according to families or subfamilies, will fall within the Torrid zone, excepting a single family of the Pinno-

theridæ, which contains eight species in the Torrid zone and fifteen in the Temperate. Considering the genera, however, we find that several among the Grapsidæ may be called cold-water genera, or are about equally divided between the Torrid and Temperate zones. They are as follows:

	Torrid species.	Temp'te species.
Pseudograpsus,	1	2
Heterograpsus,	0	1
Brachynotus,	0	1
Planes,	2	2
Hemigrapsus,	4	5
Cyrtograpsus,	0	1
Chasmagnathus,	2	2

Five out of twelve species of Grapsus also reach into the colder seas. Further particulars will be gathered from the tables.

XIII. The Leucosoids include as cold-water genera the following:

	Torrid.	Temperate.
Genus Ebalia,	0	8
" Ilia,	0	1

The other genera are mainly confined to the Torrid zone; out of the species they contain, sixty-seven in all, forty-eight are of this zone. *Hepatus*, however, contains as many cold-water as warm-water species, and the same is true of *Dorippe*, although but one of the species of the latter is exclusively Temperate.

XIV. The tropics afford not only a larger number of species of Brachyura than the temperate zone, but also a much greater proportion of individuals of the several species. Crustacean life, of this tribe, is far the most prolific in the warm waters of the globe. Species are very abundant about coral islands, far exceeding what may be found in other regions.

XV. The actual mass of Brachyura appears also to be the largest in the tropics, although there are genera, as Macrocheira and Cancer, which have their largest species in the colder waters, and which exceed in size any other Brachyura. The genera Atergatis, Carpilius, Xantho, Menippe, Zozymus, Eriphia, Thalamita, Charybdis, Calappa, besides others of the Torrid zone, contain many large species, which are of very common occurrence; while the cold-water genera of Maioids appear to be much less prolific in species, and the other genera, though abounding in individuals, as Cancer and Lupa, are still but few in number. Any very exact comparison, however, of the two zones in this particular cannot be made without more data than have yet been collected.

II. ANOUMOURA.

XVI. The Anoumoura are nearly equally divided between the torrid and temperate zones, there being hardly *one-tenth* more torrid than cold-water species. Only fifteen species out of two

hundred and twenty-five are common to the torrid and temperate zones.

Yet it is seen from the table, that if we except the Galatheidea, Lithodea, and part of the Paguridea, the species hardly extend beyond the warmer half of the temperate zone. There are but six known frigid species, and these are of the two last-mentioned groups.

XVII. The torrid zone and temperate zone sections of the Anomoura, are as follows; the frigid zone species being here added to the temperate.

1. TEMPERATE ZONE SECTION.

	Torrid zone.	Temperate zone.
Dromidæ, G. *Latreillia*,	0	3
Homola,	0	2
Bellidea,	0	2
Raninidea, G. *Notopus*,	0	1
Lyreidus,	0	1
Hippidea, G. *Albunhippa*,	0	2
Lithodea,	0	10
Porcellanidea,	27	20
Paguridæ, G. *Paguristes*,	3	6
Bernhardus,	3	29 { 1 torrid and 4 frigid.
Ægleidea,	0	2
Galatheidea, G. *Munida*,	0	2
Grimothea,	0	1
Galathea,	5	4

2. TORRID ZONE SECTION.

	Torrid zone.	Temperate zone.
Dromidæ, G. *Dynomene*,	1	0
Dromia,	8	2 (1 torrid).
Cymopolidæ, G. *Cymopolia*,	1	1
Caphyra,	2	0
Raninidea, G. *Raninoides*,	1	0
Ranina,	1	0
Ranilia,	1	0
Cosmonotus,	1	0
Hippidea, G. *Albunæa*,	3	3 (2 torrid).
Remipes,	5	1 (1 torrid).
Hippa,	2	2 (1 torrid).
Paguridæ, G. *Diogenes*,	5	2 (2 torrid).
Pagurus,	14	7 (1 torrid).
Calcinus,	6	0
Aniculus,	1	0
Clibanarius,	19	4
Cancellus,	1?	0?
Cenobitidæ,	10	1

The Dromidea and Paguridea have *one-third* to *one-fourth* more torrid than cold-water species.

The Raninidea and Hippidea are mainly tropical. The two extra-tropical species of Raninidea occur only in the warmer of the temperate regions, and the species of Hippidea in the temperate zone (eight out of the whole number fourteen) have among them four that occur also in the tropics.

The Lithodea belong to the coldest temperate regions, abounding especially in the subfrigid region. The Galatheidea are mainly of the temperate zone; there are five known torrid species, and seven temperate, the latter pertaining to the colder seas.

The genus *Porcellana* has but two-thirds as many species in the temperate as in the torrid zone. Yet the subtemperate region contains but one less than the subtorrid, and some of the largest species of the genus occur here; while, on the contrary, the torrid-zone species are quite small. Although, therefore, Porcellana may rank as a torrid zone genus, if we consider the relative number of species in the two zones, it is more properly a temperate zone genus.

The Paguridea range through both the tropics and temperate zone, even passing into the frigid zone. *Bernhardus* is mainly a cold-water genus, while Pagurus, Calcinus, and Clibanarius are mostly torrid genera. *Pagurus* has seven out of twenty-one species in the temperate zone. But it is in the torrid zone where the species of the largest size occur; the extra-torrid species belong almost exclusively to the Mediterranean. The species are exceedingly prolific in the tropics, far exceeding what occurs as regards any Paguridea in the temperate zone.

XVIII. It was found in the Brachyura, that the highest species among the Maioids, and the highest of Crustacea occur in the *extra-tropical* regions; and that as we descend to the Cancroids, the species become mainly *tropical;* moreover, as we descend among the Cancroids (the type of which is tropical), there is in general a return to the less genial colder waters, as exemplified in the true Cancers or Cancridæ and the Corystoidea, these last being mainly cold-water species. By these steps we find the more degraded forms among the Brachyura occurring in both the colder and warmer waters. We cannot therefore expect that the Anomoura, which are properly Brachyura of a still lower grade, should be arranged according to rank in one zone in preference to the other. And it is a fact that the genera of higher species occur about equally in the two zones. Latreillia, but a single step below the Inachidæ, is found in the warmer temperate regions; and Dromia, a little lower, has three-fourths of its species in the tropics. Homola, again, has been found only in the temperate zone.

Among the Paguridea, the Bernhardi or cold-water species are probably the superior in rank; and the Lithodea, which are a grade higher still, are from the neighborhood of the frigid zone.

The Hippidea, which we have considered as in the Corystoid series, but below the Corystoidea, are mostly from *warmer* waters.

The most bulky forms among the Anomoura are found in the genera Lithodes, Ranina, and Dromia. The common *Ranina dentata* has a length of five inches in the Japan Seas, while in

the warm East Indies (at the Moluccas), as De Haan states, four inches is the greatest length.

III. MACROURA.

XIX. The Macroura, according to the table, [see Report,] are nearly equally divided between the torrid and extra-torrid zones, the former including one hundred and forty-seven species, and the latter one hundred and fifty-three species.

In the table we have not included the fresh-water Astacidæ, as we are treating only of marine species. Yet in a comparison of numbers between the zones, these should be brought in. They are about thirty-six in number, and all, excepting perhaps one, belong to the temperate zone as regards the temperature of the waters they frequent. With this addition, the numbers become 147 for the torrid zone, and 189 for the extra-torrid. Sixteen of the cold-water species are common to both the torrid and temperate zones, and twenty-nine occur in the *frigid* zone, twenty-seven being peculiar to this zone. This is strikingly in contrast with the Brachyura, of which two-thirds are torrid species, and only five or six are known to extend into the cold zone, of which but *one* as far is known, is confined to it.

XX. The Thalassinidea are mainly extra-torrid species.

The Astacidea are divided between the warm and cold seas; the Palinuridæ and Scyllaridæ being mostly of the former, and the Astacidæ almost exclusively of the latter.

The Caridea spread largely over both zones; but extensive groups are extra-torrid, and some genera contain many frigid species.

The Penæidea are mainly of the torrid zone.

The exact ratios may be gathered from the tables.

XXI. The geographical relations of the subordinate groups are shown in the following table.

1. TEMPERATE AND FRIGID ZONE SECTION.

	Species in the Torrid zone.	Species in the Temperate and Frigid zones.
Thalassinidea,	6	17
Astacidea,	24	50
Astacidæ,	1	46
Scyllaridæ, G. *Arctus*,	0	1
Palinuridæ, G. *Palinurus*,	2	3
Caridea.		
Crangonidæ,	2	25
Atyidæ, *G. Ephyra*,	0	2
Palæmonidæ.		
Alpheinæ, G. *Betæus*,	1	4
Alope,	0	1
Athanas,	0	1
Hippolyte,	8	37 (19 frigid).
Pandalinæ, G. *Pandalus*,	0	4 (2 frigid).
Palæmoninæ, G. *Cryphiops*,	0	1
Pasiphæidæ, G. *Pasiphæa*,	0	3 (1 frigid).
Penæidea, G. *Eucopia*,	0	1 (frigid).

2. TORRID ZONE SECTION.

	Species in the Torrid zone.	Species in the Temperate and Frigid zones.
Astacidea.		
Scyllaridæ, except *Arctus*,	10	2
Palinuridæ, G. *Panulirus*,	12	1
Caridea.		
Atyinæ,	8	1
Palæmonidæ.		
Alpheinæ, G. *Alpheus*,	31	7
Palæmoninæ, G. *Pontonia*,	4	2
Œdipus,	3	0
Harpilius,	1	0
Anchistia,	3	0
Palæmonella,	2	0
Palæmon,	32	19 (1 frigid).
Hymenocera,	1	0
Oplophorinæ,	3	1
Penæidea,	19	12

XXII. Considering the Scyllaridæ and Palinuridæ as the Macroura highest in grade, this division of the Podophthalmia appears at first to have its superior developments in the tropics. But it may still be questioned whether this is altogether true. The Palinuridæ include two genera, one *Palinurus*, mainly a cold-water genus, the other *Panulirus*, a warm-water or Torrid zone genus; and is the Torrid zone genus the superior in rank, as should be the case, if the tropics are the most congenial to the highest Macroural developments? *Palinurus* has the outer antennæ nearly in contact at base, and the flagella of the inner antennæ are very short; *Panulirus*, the warm-water genus, has the outer antennæ remote at base, and the flagella of the inner antennæ very long. The genera are thus characterized by marks analogous to those that distinguish the higher and lower species among the Brachyura, or that exhibit the superiority of the Brachyura as a class over the Macroura; and if such evidence is here to be regarded, the cold-water genus, Palinurus, is the higher in rank. Moreover, the aspect of the Palinuri, the harder shell and more compact body, strike the eye at once as indicating their higher character. In size, they are not at all inferior; they even exceed the Panuliri in bulk if not in length. Among the Palinuri, one species is afforded by the warm seas of the West Indies; but it is not half the size lineally, of the *Lalandii* of the Cape of Good Hope, or the *vulgaris* of the Mediterranean, both gigantic species, sometimes a foot and a half in length independent of the antennæ.

The Astacidæ, the remaining family in the tribe Astacidea, is confined almost wholly to the colder waters, and the species are numerous.

Among the Caridea, the Crangonidæ certainly have the precedence. The fact that the first pair of legs have perfect hands, while the other legs are vergiform, shows a relation to the Brach-

yura, which is evidence of superiority. These Crangonidæ, thus the highest of the Caridea, are almost exclusively cold-water species.

In the family Palæmonidæ, some genera have the anterior legs furnished with stout hands, while in others the second is the stout chelate pair. The former, for the reason just alluded to while speaking of the Crangonidæ, and elsewhere further explained, are superior in rank. It is among these genera of this superior grade, the Alpheinæ, that we find the cold-water and boreal species. The genus Hippolyte alone contains thirty-seven cold-water species, nineteen of which are of the Frigid zone; and there are only eight torrid species.

On the contrary, among the Palæmoninæ, the inferior group, there are forty-six torrid to twenty-two extra-torrid species; and only one of the latter is boreal. Species of Alpheus are common in the tropics about coral-reefs; but the largest species of the genus, two or three inches long, occur beyond the tropics.

The Penæidea, the lowest of the tribes of Macroura, are mainly tropical. Yet, the very lowest species (like the lowest Brachyura) occur partly in the colder waters, or even in the Frigid zone.

XXIII. Comparing the torrid and temperate species of Macroura, we are led to conclude, that the latter are probably most numerous in individuals, and the most bulky in mass. Excepting the Panuliri, Scyllari, and some Palæmons, the tropical species are small, and moreover, they are not particularly abundant about coral-reefs. The species of the torrid genera, Pontonia, Œdipus, Harpilius, Anchistia, Palæmonella, Hymenocera, and Atya, are all quite small, the greater part not exceeding an inch and a quarter in length; moreover, the tropical Alphei are also small species, as stated above. The Penæidea are partly larger species. Contrast these particulars with the facts as to the genera of the Temperate zone. Palinurus, Astacus, Nephrops, Paranephrops, Homarus, Arctus, Crangon and the related genera, Hippolyte, Pandalus, Cryphiops, contain species mostly of large size, and the adult Homari and Palinuri are not exceeded in weight by any other Macroura.

The Thalassinidea, which belong almost exclusively to the temperate regions are smallest in the warmer part of the Temperate zone, and larger in the middle and colder part. A Puget Sound species (subfrigid region) of Callianassa (C. gigas) is at least four and a half inches long, the *C. uncinata* of Chili, five inches, and the *Thalassina scorpionides* of Chili, six inches. The facts respecting this subtribe, added to those mentioned above, strengthen much the conclusion, that the cold-water genera have the largest species; for all the species are over an inch and a half in length.

IV. ANOMOBRANCHIATA.

XXIV. The Mysidea, to which the Penæidea are related, are, to a considerable extent, cold-water species, although many are found also in the tropics. There are among them twenty torrid species and seventeen extra-torrid species.

In the Squilloidea we have an example of an inferior grade in a large lax body, with a small head and long abdomen; and they remind us of overgrown larval forms, or species vegetatively enlarged beyond the normal or most efficient size. In this particular they have some analogies with the earlier forms of life. They are found mostly within the tropics. Twenty-four of the Squillidæ are torrid zone species, and only seven pertain exclusively to the Temperate zone. Of the Erichthidæ, twenty-one out of twenty-two species are reported from the Torrid zone. The Amphionidea, a related group, include seventeen Torrid zone species and two of the Temperate zone.

(To be continued.)

ART. XXXV.—*Notes on Map Projections*;* by Lieut. E. B. HUNT, Corps of Engineers, U. S. A.

MAP PROJECTIONS CLASSIFIED AND DEFINED.

THAT department of descriptive geometry, or analysis, which treats of map and chart projections, has to deal solely with the terrestrial spheroid, and especially with the representation of the parallels and meridians subdividing its surface. As all localities, both on land and sea, are most readily and generally determined by latitude and longitude observations, so it is the most available and universal method, in constructing maps, to refer all positions to meridians and parallels as coördinate lines.

If we conceive the earth's surface reticulated by a complete framework of parallels and meridians, it is then the specific and uniform object of all modes of projection to represent these lines on a plane surface, in the most advantageous manner. But, as the spheroid is incapable of direct development on a plane, it only remains to present, in projection, the *best* approximation to similitude in form, relation, and proportional area in the parts of the earth's surface to be represented.

Ptolemy, Lambert, Euler, Lagrange, De l'Isle, Monge, La Croix, Puissant, Henry, Gauss, and others, have treated of projections in more or less detail, and some of them by methods of

* Extracted with modifications from the Coast Survey Report for 1853, in which is also included the formulæ for polyconic projections, with full tables and a description. The Tables suffice for the entire United States on either a large or small scale.

the highest grasp and compass.* This general problem has led to the following modes of projections, (all technically, though some quite incorrectly so called,) each of which has been used, and most of which possess advantages for some descriptions of maps or charts. This classified synopsis will serve to show more precisely the relative value and precise character of the polyconic projection.

Class I.—Perspective projections on planes,	Orthographic. Globular, or equidistant. Stereographic. Gnomonic, or central.
Class II.—Developed perspective projections,	By a tangent cylinder. By a secant cylinder. By a tangent cone. By a secant cone.
Class III.—Projections by developing elements,	Cassini's. Flamstead's. Bonne's, or the modified Flamstead's. Polyconic, (U. S. Coast Survey.)
Class IV.—Projections conformed to some arbitrary condition,	The flat chart, with equal latitude degrees. The flat chart, with latitudes = radius × sine of latitude. De Lorgna's. Ptolemy's modified conic. Mercator's.

CLASS I.

All simple perspective projections are made by supposing the eye at some particular point, and the plane of projection or representation to be pierced by all the rays, or rays prolonged, between the eye and all points of the parallels and meridians. The curves composed of all these piercing points of rays constitute a perspective projection. A projection is practicable for any possible position of the eye or plane, (except when the eye is in the plane,) but only a few among this infinite number of perspectives are convenient or eligible for construction.

In the *orthographic* projection the eye is assumed at an infinite distance, and the projecting rays are parallel lines to which the plane of projection is perpendicular at any point desired. By this method circles are projected into ellipses, and the outer parts of the projected hemisphere are very much crowded.

In the *globular* or *equidistant* projection, originated by La Hire, the eye is placed at a distance from the centre of the earth = Radius + sine $45° = (1+\sqrt{\frac{1}{2}})$ radius. The plane of projec-

* Reference on this subject may be made with advantage to the following general treatises: Puissant, "Traité de Topographie," 1805; Henry, "Memoire sur la projection des Cartes," 1810; "Memorial du Depot de la Guerre," tome ii. and iv; La Croix, "Precis Astronomique," in "Pinkerton's Geography;" Barbié Dubocage, and La Croix, vol. i, "Memorial Topographique et Militaire," Francoeur's "Traité de Geodesie;" Gehler, "Physickalisches Worterbuch;" Mayer's "Practical Geometry," 1828; "Littrow's Astronomy," 1812; Narrien's "Astronomy and Geodesy," 1845; Jackson's "Chartography," in "Manual of Geographical Science," 1852.

tion passes through the centre perpendicular to the central ray. This projection obviates the orthographic contraction or crowding and the stereographic exaggeration in the outer rim of a projected hemisphere.

In the *stereographic* projection, the eye is taken on the surface of the earth at the pole of the great circle used as a plane of projection. Circles are stereographically projected into circles. An increasing exaggeration of parts from the centre outwards is its great defect.

In the *gnomonic* or central projection, the projection is on a tangent plane—the eye is taken at the centre of the sphere. Great circles are gnomonically projected into straight lines, and all small circles into curves of the second order or conic sections. The entire hemisphere cannot thus be projected, and the portions become rapidly exaggerated in receding from the tangent points.

CLASS II.

Instead of projecting directly on planes, an intermediate cylinder or cone is employed in this class to receive the projection, which is then developed or rolled out on a tangent plane. The cylinder and cone being the only surfaces which can be developed by simple rolling out, and without elementary resolution, this class always requires the auxiliary use of one of these surfaces, which may be assumed, subject to several different conditions.

The projection on a *tangent cylinder* for development is made by placing the eye at the centre of the earth, and projecting the parallels and meridians on a cylinder tangent around the equator. On development, the parallels and meridians are found projected into perpendicular straight lines.

A *secant cylinder* may be so determined that the entire area of the spherical zone projected shall be exactly equivalent to its projection. These methods are limited in their advantageous application to a moderate equatorial belt.

In projecting perspectively on a *tangent cone* for development, the eye is assumed at the earth's centre, and the cone is taken tangent around the middle parallel of the zone to be projected. On developing this cone, the meridians appear as straight lines radiating from its vertex, and the parallels as circular arcs concentric around this point, the middle parallel being in its true length.

A *secant cone* may be taken which will give two parallels of correct length in the development, and much reduce the distortion of the extreme belts. This method of Ptolemy was revived by Mercator, and was used by De L'Isle in his map of Russia. Murdoch proposed to make the area of the conic frustum used equal to that of the projected spherical zone—a good condition, though inconvenient in construction. De L'Isle proposed to use a cone, through the limiting parallels. Euler proposed and de-

termined the cone which equalizes the errors and distortion on the central and the two limiting parallels. The use of two conic frustums—one for the north and one for the south half—has also been attempted, and advocated.

CLASS III.

The class of projections in which portions of the spherical surface are developed by being resolved into their differential elements, which are successively developed, is characterized by a peculiar elegance, and is of the highest importance. By this means, any portion of a spherical or spheroidal surface may be reconstructed on a plane with the most perfect attainable preservation of the relations and dimensions of its parts. This class of projections is far the best for representing limited areas, and can even be extended with advantage in some forms to *mappemondes*, or maps of the entire earth's surface.

Cassini's projection is made by first developing the central meridian of the area for projection into a straight line. A series of prime verticals or great circles perpendicular to their central meridian is passed at elementary distances along the meridian arc, all of which circles intersect in the spheric poles of the central meridian. These divide the surface into elementary rectangular isosceles triangles, or sectors, basing on the meridian elements. When the meridian is developed, these elementary triangles are conceived to be carried with it, and then to be severally developed into plane triangular elements. The elementary opening out between these developed areas may be neglected for some distance from the central meridian. Accordingly, a series of perpendicular straight lines through the graduations of the developed central meridian is taken as a substitute for parallels, and may be used as far as the opening out between elements can be neglected. Cassini's Map of France is thus projected; but, as its inaccuracy on the extreme east and west sheets amounts to 150 toises in 40,000, the use of this projection is not to be recommended for areas thus extensive. Du Séjour has developed the theory and formulæ of this method. As parallels of latitude do not enter, the latitudes of places must be derived indirectly, except on the central meridian.

Flamstead's projection is based on a resolution of the earth's surface into elementary zones or rings by parallels of latitude taken at successive elementary distances laid off along the central meridian of the area to be projected. Having developed this centre meridian on a straight line of the plane of projection, a series of perpendiculars is conceived to be erected at the elementary distances along this line. On or between these perpendiculars the elementary zones are conceived to be developed in their correct relations to each other and to the central meridian. Each

zone being of uniform width, occupies a constant breadth along its entire developed length, and consequently the area of the plane projection is exactly equal to that of the spheroidal surface thus developed. This demonstration applies directly to an analogous plane development of the surface of all supposable surfaces of revolution, be the generating meridian curve what it may, and even though the generatrix be one of double curvature. The meridians of the developed spheroid are traced through the same points of the parallels in which they before intersected them. They all cut the parallels obliquely, and are concave towards the central meridian. Thus, while each quadrilateral between parallels and meridians contains the same area and points after developments as before, the form of configuration is considerably distorted in receding from the central meridian, and the obliquity of intersections between parallels and meridians grows to be highly unnatural.

Bonne's, or the *modified Flamstead's* projection, to a great extent obviates this defect. It is the same as Flamstead's, except that the elementary zones, instead of being developed on right lines, are rolled out on concentric circular arcs described from the vertex of the cone tangent along the central parallel for their common centre. The great importance and wide use of this method induce a more detailed treatment of it under a subjoined heading.

The *polyconic projection*, being that for which the Coast Survey tables are prepared, will be specially explained further on in its proper place.

CLASS IV.

In addition to the perspective projections, the developed perspective, and the elementary development projections, there is a class in which some extraneous, arbitrary mathematical condition is imposed, giving rise to constrained or distorted delineations. The assumed condition is usually due to some practical consideration.

The *flat-chart* projection, with *equal latitude* degrees, is a rude method once much in use for charts. Two sets of equidistant perpendicular lines, composing a series of equal squares, were arbitrarily assumed as parallels and meridians to which all localities were referred by latitudes and longitudes. Hence resulted a gross distortion of figures, areas, and directions.

Another *flat-chart* projection was sometimes used, in which equidistant straight lines served as meridians; and for parallels a second set of straight perpendiculars at distances from the equator equal to those of the respective terrestrial parallels for which they stand. This is a radial projection on the circumscribing cylinder tangent along the equator, the radii of parallels being the only

projecting lines. Hence resulted a very distorted picture, but one in which each quadrilateral contains an area equal to and corresponding with its spherical correlative—a direct result of the relation between the sphere and circumscribing cylinder. This was the sole recommendation of the method.

De Lorgna's projection is chiefly employed as a polar projection of a hemisphere, for which use it is well adapted. A circle is determined equivalent in area to the hemisphere to be projected. Radii drawn to the graduations of its circumference represent meridians. A radius, graduated into ninety equal parts, is sometimes used as the latitude scale; but the chords of the polar distance of the parallels should be always employed. Hence results equality of areas between the projected and resultant quadrilaterals in general. Outlines are traced by latitudes and longitudes, as usual. For projecting a polar hemisphere, this method is most excellent, as rectangular intersection is combined with conservation both of figure and area.

Ptolemy's modified conic projection is made by using the concentric parallels of the pure conic development, and tracing curved or elliptical meridians across these in place of radial lines. By turning the convexities of these curves from the central line, and by skillful choice of curves, much of the distortion due to the extension of extreme parallels in development is obviated. This projection has been much used for maps of Asia, Africa, and America.

Mercator's projection is truly invaluable for navigators in laying long courses when out of sight of land, as these courses are always straight lines on the chart. Meridians are represented by equidistant parallel straight lines, and the parallels by a perpendicular set of parallel straight lines, whose distances from each other increase from the equator towards the poles in precisely the same ratio as the corresponding longitude degrees diminish. This projection results from the development of a cylinder tangent along the equator; the meridians being projected on their tangent elements, and the parallels being assumed as circles of right cross section at distances from the equator equal to the meridian arc of latitude divided by the cosine of the latitude—the earth's compression being neglected. By this means the relation of length between the latitude and longitude measurements on the chart is preserved uniformly the same as it is on the earth's surface. Tables of the increasing degrees have been computed, and are in general use for laying down parallels. Distances and areas are increasingly exaggerated and distorted as this projection is pushed towards the pole, making the scale very variable from point to point of an extended chart; but as the navigator computes his distance run, this variable scale is not by any means so serious a defect as to offset the invaluable facility with which

Mercator's principle enables him to run directly from one point to another. For the polar portion of the earth in which this projection totally fails, a central projection can be used to some distance. A projection on Mercator's principle might be made relative to the prime meridian instead of the equator, its prime verticals serving as the equidistant parallels, (as in Cassini's) and the circles parallel to the prime meridian being projected by the table of increasing degrees. This would require the investigation of the formulæ for conversion of coördinates in this case. The parallels and meridians of the earth might then be constructed by points. Another mode would be to make a radial and concentric circular projection around the pole, in which the length of the latitude degree should be deduced from the same condition as in Mercator's method, the divergence of meridians being duly considered. The amount of distortion in Mercator's projection wholly unfits it for land maps; and the variation of its scale in different parts would give rise to endless inconvenience were it applied to any other purpose than that of nautical offshore charts, in which direction is so much more important than area or distance.

BONNE'S OR THE MODIFIED FLAMSTEAD'S PROJECTION.

This method of projection is that which has been almost universally applied to the detailed topographical maps based on the trigonometrical surveys of the several States of Europe. It was originated by Bonne, was thoroughly investigated by Henry and Puissant in connexion with the map of France, and tables for France were computed by Plessis.

In constructing a map on this projection, a central meridian and a central parallel are first assumed. A cone tangent along the central parallel is assumed, the central meridian is developed on that element of this cone which is tangent to it, and the cone is then developed on a tangent plane. The parallel falls into an arc with its centre at the vertex, and the meridian into a graduated right line. Concentric circles are conceived to be traced through points of this meridian taken at elementary distances along its length. The zones of the sphere lying between the parallels through these points are next conceived to be developed each between its corresponding arcs. Thus, all the parallel zones of the sphere are rolled out on a plane in their true relations to each other and to the central meridian, each having in projection the same width, length, and relation to its neighboring zones, as on the spheroidal surface. As there are no openings between consecutive developed elements, the total area must in this case, and in all like developments of surfaces of revolution, remain wholly unaltered by the development. Each meridian of the projection is so traced as to cut each parallel in the same point in which it intersected it on the sphere.

If the case in hand be that involving the greatest extension of the method, or that of the projection of the entire spheroidal surface, a prime or central meridian must first be chosen, one half of which gives the central straight line of the development, and the other half cuts the zones apart, and becomes the outer boundary of the total developed figure. Next, the latitude of the governing parallel must be assumed; thus fixing the centre of all the concentric circles of development. Having then drawn a straight line and graduated it from 90° north latitude to 90° south latitude, and having fixed the vertex or centre of development on it, concentric arcs are traced from this centre through each graduation. On each parallel the longitude graduations are then laid off, and the meridians are traced through the corresponding points. There results from this process an oblong kidney-shaped figure, which represents the entire earth's surface, and the boundary line of which is the double developed lower half of the meridian first assumed. If the vertex of the governing cone be removed to an infinite distance, the equator becomes the governing parallel, the parallels all fall into straight lines, and Flamstead's projection results. The kidney-shaped figure becomes an elongated oval, with the half meridian for one axis, and the whole equator for the other. A somewhat similar figure is obtained by placing the vertex at the pole, and reducing the tangent cone to a plane. An indented cusp at one end, and a rounding out at the other, will give an approximate pear-shape. Ptolemy's modified conic method reaches its full geometrical result in these forms, derived from the condition of *preserving areas* in tracing meridian curves.

Bonne's method is rarely applied to areas exceeding the limits of a State, but is invaluable for topographical maps of this description. The projection is made at once for the whole territory of the map, and the rectangular system of sheets laid out on the projection. Each sheet is numbered, and the coördinates of the corners are determined, so that the coördinates of intersection between parallels and meridians falling on each sheet are referred to its neat lines as axes.

This projection preserves in all cases the areas developed without any change. The meridians intersect the central parallel at right angles; and along this, as along the central meridian, the map is strictly correct. For moderate areas, the intersections approach tolerably to being rectangular. All distances along parallels are correct; but distances along the meridians are increased in projection in the same ratio as the cosine of the angle between the radius of the parallel and the tangent to the meridian at the point of intersection is diminished. Thus, in a full earth projection, the bounding meridian is elongated to about twice its original length. While each quadrilateral of projection preserves

its area unchanged, its two diagonals become unequal; one increasing and the other diminishing in receding towards the corners of the map, the greatest inequality being towards the east and west polar corners. Though great circles between stations on the earth are generally projected into curves, the amount of deviation for moderate limits is very slight on a Bonne projection. The scale is nearly uniform over the entire projection, being accurate along the parallels and along their radii, but being too great along one diagonal of the quadrilaterals, and too small along the other. In an area of 120° longitude and 70° latitude, a distance of 7,000 miles is in error but $\frac{1}{32}$th. This projection has thus many excellent qualities for topographical maps; and its defects of oblique intersections, of unequal diagonals, and of scales varying with the point of the compass, are not very serious in a limited area, as in the map of France, or that of England and Wales. A special set of tables for each central parallel is required in this method; and the extent of these is so vast as to make impracticable the conception of a universal set of tables. The French tables of Plessis are based on the parallel of 50gr. or 45°, and are available for any area centered on this line, except that the old compression was used in computing them. But to construct tables for Bonne's projection for use in the disconnected local maps of our country was impracticable, as no central parallel could be assumed for them all. Were a general topographical map of the United States to be made, a central parallel might be assumed for that purpose; but even in this case the question should be carefully weighed, whether the Bonne projection would be as desirable as the rectangular polyconic.

THE POLYCONIC PROJECTION, ITS PROPERTIES AND VARIETIES.

The operations of the coast survey being limited to a narrow belt along the seaboard, and not being intended to furnish a map of the country in regular uniform sheets, it is preferred to make an independent projection for each plane-table and hydrographic sheet, by means of its own central meridian. These sheets embrace areas so limited as to exhibit in projection no sensible distortion of figure, and they individually agree with nature far more perfectly than they would if arranged as parts of a rectangular series projected on Bonne's method. In fact, each sheet is projected strictly as a local map, and its connexion with the adjoining sheets is established solely by the points of triangulation. In reductions, including several sheets, the plotting of points is the first step, and the change of scale is then made by corresponding squares. By the aid of the coast-survey tables, a *rectangular polyconic* projection can at once be made for each locality or subdivision of the United States, or for the United States as a whole.

The name *rectangular polyconic* projection is applied to the method in which each parallel of the spheroid is developed symmetrically from an assumed central meridian by means of the cone tangent along its circumference. Supposing each element thus developed relative to the common central meridian, it is evident that a projection results in which all intersections of parallels and meridians take place at right-angles.

Let the most general case, or that of the entire spheroid, be first assumed, the development being made, for instance, relative to the meridian of Washington. Starting at the north pole, the tangent cone there has then its limiting form, or it coincides with the tangent plane. Taking then the elementary parallels successively southward, the vertex of the moving tangent cone recedes along the prolonged earth's axis, giving to the developed parallels a receding centre and an increasing radius as the latitude diminishes. At latitude 45° the terrestrial and development radii become equal. At the equator the vertex recedes to an infinite distance north, or the cone becomes a cylinder, and the equator falls in a straight line perpendicular to the meridian. On passing to the south the vertex approaches from an infinite distance south, the parallels change their concavity southward, while the curvature, increasing in an inverse order, becomes infinite at the pole, or the polar parallel falls in a point. There results from this process a biaxial figure, with four equal quadrants, the short axis being the rectified Washington meridian, (180° in length) and the long axis being the entire rectified equator, or about twice the length of the shorter one. A re-entering cusp marks the bounding curve at each pole, and the meridian, 180° from Washington, which circumscribes each half of the figure, is elongated on each side to more than twice its original length by the development. Over the entire area of this projection all parallels and meridians intersect at right angles, and the diagonals of each projected quadrilateral are everywhere nearly equal to each other. The scale on N. and S. lines near the border is somewhat enlarged, but is very correct on E. and W. lines, while along both diagonals it is somewhat enlarged, though nearly equally so on each. On the whole there results from this method much less of local distortion than from Bonne's projection. Equality between the spheroidal and developed areas is not preserved, but the departure from equivalency is not great in amount.

As rectangular intersections and preservation of areas are not both attainable at once, it becomes a question of preference between them in each case. It is also a question whether it might not in some cases be advantageous still further to sacrifice the preservation of areas so as to make the same scale applicable in all azimuths at each point. This would require the longitude degrees to increase from the centre meridian outwards in the

same ratio as the corresponding projected meridional degrees. This condition would determine a new polyconic projection, whose scale, from point to point, (an element which in Bonne's, and the simple polyconic projection, is a function both of the central meridian distance, and azimuth) would become a function of the central meridian distance only, and would increase alike in all directions on receding from this line. Such a projection would reduce distortion of local configuration, to an absolute minimum, and the areas in projection would be proportional to the squares of their local graphic degrees. This would enable us to take strict account of those irregularities of scale which now lurk in disguise. But it would be a great labor to prepare the tables requisite for its ready use, and there would be some valid objections to its results. In a large topographical map thus projected, the scale of each sheet could be derived and engraved on its plate, making the sheet quite homogeneous on that scale, and perfect in the preservation of its configuration. Were a topographical map of the United States to be undertaken on a liberal scale, this projection might be found superior to any other, as in each sheet areas, dimensions, relations, and rectangular intersections, would be well preserved according to its own scale, giving it the greatest local perfection, while it would also combine correctly in its proper place. It should be stated that this projection is novel and untried.

The method of projection in common use in the Coast Survey office for small areas, such as those of plane-table and hydrographic sheets, may be called the *equidistant polyconic.* This ought to be regarded rather as a convenient graphic approximation, admissible within certain limits, than as a distinct projection, though it is capable of being extended to the largest areas, and with results quite peculiar to itself. In constructing such a projection the central meridian and a central parallel are chosen, and they are constructed just as in the rectangular polyconic method. The top or bottom parallel, and a sufficient number of intermemediate ones to determine the meridians with proper correctness, are constructed by the tables, and the meridians are drawn. Then starting from the central parallel, the distance to the next parallel is taken from the central meridian and laid off on each other meridian. A parallel is traced through the points thus found. Each parallel is constructed by laying off equal distances on the meridians in like manner, and the tabular auxiliary parallels are, all except the central one, erased. In fact, as only the points of intersection are required, the auxiliary parallels should not be actually drawn. From this process of construction results a projection in which equal meridian distances are everywhere intercepted between the same parallels.

If we conceive this projection extended to include the entire earth, a singular result appears. Taking the equator as the central parallel, all the parallels become concave towards this line; for the distance between parallels measured along the curved meridians being constructed equal to that along the central straight meridian, it is evident that the parallels must converge in receding from the central meridian. The parallel of 90°, or the polar point, becomes extended into a curve, whose length approaches that of the developed equator. It will be seen that each parallel falls nearer the equator than it would in Flamstead's projection, being, indeed, tangent on the equatorial side of the Flamstead perpendicular. Thus, in this method the projected area is less than that of the spheroidal surface. If an equidistant polyconic projection be made on the same central meridian and parallel as a Bonne projection, its area will in like manner be less for each rectangle and for the aggregate; hence this projection, where extended to a great surface, always gives its area too small. It also makes its meridian arcs unduly short, and the extreme parallels much too long; giving a grotesqueness to the polar regions bordering on that of a Mercator projection. The scale becomes in some parts excessively dependent on azimuth; the distortion in the polar corners is very great; the intersections are far from rectangular, and they are so conditioned as not to be readily computed. From these defects, so gross in the developed spheroid, and still great even in a map of the United States, it is clear that the *polyconic-equidistant* projection ought by no means to be extended beyond the most moderate limits. A square degree, on a scale of $\frac{1}{1000}$, may be taken as a limit, beyond which no convenience of graphic construction should induce the use of this approximation. Beyond this limit the *rectangular-polyconic* method should be employed, at least in all Coast Survey projections.

The polyconic method of projection has been developed in the Coast Survey office, and tables, prepared for facilitating its use, were there computed, and are now first published in the Report for 1853.

GRAPHIC CONSTRUCTION OF POLYCONIC PROJECTIONS—COAST SURVEY METHODS.

Having fixed the limits to be covered by the projection, the central meridian is represented by a straight line, as nearly as practicable, through the centre of the sheet. From an assumed starting-point on this line are laid off the successive meridian arcs, as taken from the tables.

Rectangular polyconic method.

Through each point of division on the central meridian, given by these tabular arcs, erect a perpendicular to it by means of a

well-tested right-angled ruler, with twenty-four inch legs, and a hard pencil; or first carefully construct a single accurate perpendicular by sweeping intersecting arcs with the beam-compass, and then draw on each side a parallel to the central meridian, on which lay off the meridian distance from the perpendicular, and draw the parallel lines through the three equidistant points thus obtained for each. Take from the tables for each required point of intersection between parallels and meridians, its appropriate length of arc of parallel, from which subtract the corresponding x. Lay off this difference from the central meridian each way on its proper perpendicular, and erect, towards the pole, at the point so formed, a perpendicular equal to the corresponding value of y in the tables—its extremity is the point of intersection required. Through all the corresponding points of intersection trace the parallels and the meridians. Erase the auxiliary lines, and write on the margin the numerical latitude and longitude.

The following mode is more rapid and better checked: Lay off first the longest arcs of parallel, and then take the length of a single subdivision of the parallel in a pair of hair-spring dividers, and step it off on the perpendicular to the right and left of the central meridian, being careful not to prick the paper. Having adjusted the dividers so as to bring the extreme points thus obtained to a perfect agreement, prick lightly the subdivision points. Take from the tables the successive values of x for each point, and when these are sensible on the scale used, lay them off back towards the central meridian from the points before obtained, and erect, at the last points, perpendiculars equal to their respective values of y. As x is always small, and for some entire projections quite insensible, this method is much more convenient than that of using all the while long distances; but the check of a total measurement on each parallel is quite indispensable, as an insensible error in taking the subdivision distances grows, by repetition, to be very evident in the check measurement.

Equidistant polyconic method—(Inadmissible in projections covering more than one square degree.)

Proceed as before to graduate the central meridian, and to construct a central parallel. Construct the points of meridian intersection with the top and bottom parallels, and as many intermediate parallels as are requisite closely to determine the meridians. Through these points then draw the meridians. Starting now from the central parallel, lay off on each meridian the distance to the required parallel equal to that on the central meridian, and trace the parallels through these points. Proceed in like manner to construct the others, using always the central parallel as a base, and the totals measured from it along the central meridian in laying off.

This method requires much less recourse to the tables than the other, and is sufficiently accurate, within a square degree, on a scale of $\frac{1}{1\,0\,0\,0\,0\,0}$. The x and y may often be neglected as insensible in small projections; but no value of x, which is at all appreciable on the scale used, should be neglected. The y, for the auxiliary parallels, affects the meridian less rapidly, but its palpably sensible values should always be used.

The following quantities are sensible, yet only barely sensible, on the scales affixed:

12	metres	on a scale of	$\frac{1}{8\,0\,0\,0\,0\,0}$.
10	"	"	$\frac{1}{6\,0\,0\,0\,0\,0}$.
8	"	"	$\frac{1}{4\,0\,0\,0\,0\,0}$.
6 or 5	"	"	$\frac{1}{3\,0\,0\,0\,0\,0}$.
3	"	"	$\frac{1}{2\,0\,0\,0\,0\,0}$.
1½ or 2	"	"	$\frac{1}{1\,0\,0\,0\,0\,0}$.

These quantities are quite overshadowed in large sheets by the expansion and shrinkage of drawing-paper from day to day. In both methods the x and y should always be used for good projections when they would be sensible on the scale in use. And it is peculiarly essential to accurate projections that the hygrometric condition of the paper be kept as uniform as possible during all the time that measured distances are being laid down. It is often better to mark simply the intersection points by a small cross +, and to omit the remainder of the parallels and meridians. For plotted points this is also the best indication, if the cross lines are stopped on each side of the point, just far enough off to leave the dot distinct.

For drawing parallels and meridian curves, a long, slender, flexible ruler of straight-grained cedar, or other compact wood, is employed. Its cross section is three-sixteenths ($\frac{3}{16}$) of an inch by two sixteenths ($\frac{2}{16}$) of an inch. A specially designed steel ruler might be found preferable. There is a small groove on the top of the ruler, and its ruling edge is slightly beveled. Leaden, paper-covered, beak weights, of about four pounds weight each, are used to hold the ruler in place from point to point. These are so shaped as not to incommode the hand in ruling, and each has a hooked beak, ending in a knife-edge, turned downwards, which, resting in the ruler groove, throws the main bearing of the weight on the ruler, while its small end rests on the paper. The beak weights in use are five (5) inches long, two and one-eighth ($2\frac{1}{8}$) wide, and two and one-eighth ($2\frac{1}{8}$) deep, the beak being five-eighths ($\frac{5}{8}$) of an inch long, and turned down one-fourth ($\frac{1}{4}$) inch. The mass of lead is nearer the beak end. Having placed the ruler approximately, it is so adjusted under a beak weight to the first point that the curve will be ruled exactly through it. It is then adjusted under a second weight to the

next point, and then bent to the next in like manner, and so on until the entire curve is completed. Before ruling this the eye should criticise it carefully, as a check on graphic errors. For fine projections the hardest pencils are best; and in inking, the lines should be drawn as delicately as clearness permits.

When no metre scale is at hand, the tabulated distances can be converted into yards by using the conversion tables, or by the constants of relation between units; or, when the greatest accuracy is not important, a metre scale can readily be constructed from a yard or foot scale by proportionality. Thus, rule two parallel scales, one of yards and one of five-sixths ($\frac{5}{6}$) yards, and draw a third parallel, whose distance outside the yard-scale is $3.36\frac{8}{6}5$th of that between the yard and five-sixth yard scales. Through the similar graduations draw straight lines; these will give a metre scale by their intersections. If space permits, a point may be substituted for the five-sixths ($\frac{5}{6}$) yard scale. The projection once constructed, may be used independent of the unit of the tables.

ART. XXXVI.—*On the Educational Uses of Museums;* by EDWARD FORBES, F.R.S., &c.*

THE third Session of the Government School of Science applied to Mining and the Arts commences to-day. The Director and my Colleagues have assigned to me this year the duty of opening the courses. I shall avail myself of this opportunity to offer some remarks upon the leading and characteristic features of the Institution, considered as an educational Museum, and to make some observations upon the instructional uses to which Museums may be advantageously applied.

The school of applied sciences here established is the only instance in Britain of an organized instructional institution arising out of a Museum, and being maintained in strict connection and relation with its origin. This is not an accident, but an event contemplated from the commencement of the Geological Survey. It is an experiment on a considerable scale with a greater purpose,—for, with a limited though rapidly improving machinery, it is intended to advance educational aims that have a vital importance in their bearing on the future prospects of this country. It is an endeavor by a State-mechanism to cast the seeds of science over the broad fields of British industry,—not indiscriminately, but especially in those places where there is a good soil thirsting for their germination. We who are appointed to be

* Introductory Lecture at the Metropolitan School of Science, etc.; Museum of Practical Geology. London, 1853.

cultivators have a responsible duty and a noble task. We have firm faith in the dignity our work, and in the certainty of good results arising from it. This must be our reward; and with it we are content, as long as we can, to labor patiently and earnestly to the best of our endeavors,—hopeful of the approbation and coöperation not only of our fellow-laborers in science, but also of all intelligent and patriotic Britons.

The results so far of the teaching here have been in the main highly satisfactory. With the close of last session terminated the two years curriculum of the students who entered the Government School of Mines in 1851. Since their studies are now completed, I may speak of the men in the language not of compliment, for of that there is no necessity, but of unmixed praise. I can say this not only for myself but for all my colleagues; and we have the delightful satisfaction of anticipating a distinguished scientific and practical career for those who were lately our pupils, and whom now we number among esteemed friends. Their services are sure to be appreciated and anxiously sought for; and already we have had the pleasure of congratulating some of them on the obtainment of highly valuable and honorable posts, for which they had become qualified within these walls.

With equal satisfaction we can refer to the department of our lectures devoted to the instruction of working men. The artisans of London have eagerly and admirably responded to the opportunity so freely offered to them by Government in this Institution. They have crowded to our theatre and attended our courses with unmistakable earnestness and intelligence. To address the audience, composed exclusively of working men, assembled on these benches on Monday evenings has been a privilege and a pleasure to all of us.

The peculiar advantages which we have held out to officers of the public service, especially to officers of the army and navy, have not been neglected by the class for whom they were intended. At the same time, it was expected that more use would have been made of them. It is difficult, doubtless, for gentlemen whose duties command so much of their time, to make days and hours suit their convenience. Those who entered our classes, have been among the most diligent of students. The majority have come to us from the East India Company's service, chiefly officers of engineers and medical officers. Much might be done for the advancement of science by naval and military men when on service abroad, and much is being done by them every day as the transactions of learned societies can amply testify. An occasional course of study in one or more of the sciences taught here would enable many a soldier and sailor to occupy vacant hours with pleasure and advantage, and possibly with benefit to the general advancement of knowledge. During the time when I had the

honor of assisting on board one of Her Majesty's surveying ships, I witnessed the happiness and profit that resulted from the pleasure taken by a corps of naval officers in scientific pursuits.

It was supposed that opportunities for scientific instruction such as are here afforded would have been appreciated by intelligent persons among the middle and higher ranks, having time at command. With the exception of a chosen few, the anticipation has proved fallacious. Possibly the occult science of table-turning, which in these days seems to occupy the place filled by astrology in days of yore, has too seriously occupied their thoughts to permit of chemical, physical, geological, or biological studies. In London there are several institutions of high character, that offer, at reasonable cost, scientific instruction to the so-called "educated" classes; yet if the numbers of all, young and old, who avail themselves of the chances that are placed within their reach were to be summed up, scanty indeed would the proportion appear who appreciate, as compared with the vast majority who neglect, the opportunity. Need we wonder then at the success of popular follies and absurdities among persons to whom, if we applied the epithet "unenlightened," we should give mortal offense? There is, indeed, no stronger argument in favor of the State taking the initiative in scientific instruction of the kind given here, than the fact, that the classes of the people who cannot afford to pay high fees, or come to learn during the hours of the day, are anxious and thankful for it; whilst those who ought to support deserving institutions of private foundation have yet to be imbued with a taste for natural knowledge, before they will do that which should be at once a duty and a pleasure.

This year our resources, though still too limited, have been considerably extended, and an important and indispensable want supplied, through the institution of a lectureship on Applied Mechanics. It is with feelings of exultation that I venture to allude to the manner in which this new post has been filled. The accession to our corps of so eminent a philosopher as Professor Willis is an honor deeply appreciated by all of us. In him we feel that we have acquired a new source of strength, whose value cannot be too highly reckoned. We feel, too, that in the world of science, and in the world of mechanical industry, the approbation of this appointment is universal.

In the presence of Dr. Hofmann, who though appointed to the lectureship on Chemistry and charge of the Laboratory, since the conclusion of last session, has sat with us and served amongst us for some time, I will not—I need not—enter on any eulogium of his distinguished merits. To have secured the services of one of the most eminent of European chemists, for the post until lately so ably filled by Dr. Lyon Playfair, is as great a satisfaction to ourselves, as it will be a guarantee of good work to the public.

His predecessor has left us for a post of heavy responsibility and inestimable importance,—one on the conduct of which the success of government institutions for scientific education will in a great measure depend. He has left us with our warmest wishes for his success, and our firmest confidence in his ability, energy, earnestness, and truthfulness. But though no longer holding a professorial post here, we retain the benefit of his advice and counsel, since he still remains connected with our institution, and sits with us as a member of our Educational Committee.

We commence the session—so far as the class of students of most consequence, viz., the matriculated class, is concerned—under peculiarly favorable auspices. The number of entries is greater at this early stage of the courses than during either of the former years. Considering how difficult it is in our country for any establishment on a new plan to make way, this evidence of progress may be taken as a fair subject for congratulation.

The object of the Museum in which we are now assembled is mainly the illustration of the mineral constitution and products of the British islands, and to some extent, of the British colonies. This purpose, whether we consider the great benefit derived from mineral wealth by our nation at large, the vast capital invested in the search after and application of mineral resources, or the light thrown upon science under its nobler and less profitable forms, cannot but be esteemed a worthy one. To carry it out effectively would require more than double the space here assigned to it, and powers of speedy and comprehensive action such as are not usually conferred upon the managers of State institutions. The purpose of the place in some of its branches is more or less fully presented, but in others is barely sketched or rather indicated. The applications of mineral products to the various useful and ornamental arts are so numerous, that, except in a few principal instances, it would be folly to attempt their illustration within our confined boundaries. Consequently, in a purely industrial direction our display is sketchy and partial. That a collection fully and judiciously illustrating the arts that spring from the world of minerals, treated with equal regard to their present extension and past history, to their excellencies, capabilities, and defects, would be in the highest degree instructive and beneficial, if employed in the illustration of well-devised courses of instruction, there cannot be a doubt. If ever such a collection be formed, this institution may fairly claim the credit of its paternity.

In one of its departments this Museum aims at more amplitude; and even proceeding at our present somewhat tardy pace—inevitably so, as we are situated,—must in the end attain, or at least nearly approach, completeness. I allude to that devoted to the illustration of the geological structure of the British Islands. You are aware that we are here an establishment in intimate connex-

ion with, and many of us officers of, the Geological Survey of the United Kingdom. Perhaps the most distinctive feature of this Museum is, that it is the visible evidence of the bearings and progress of that survey. When the officers of the Royal Engineers have performed their duty as topographers, and given to the public the admirable and invaluable maps issued by the Ordnance, then the members of the corps of Government geologists go over the ground anew with the distinct and important office of delineating its mineral structure. On electrotype casts of the original Ordnance plates, the new lines traced by the officers in charge of the geology are laid down, and the new map so constituted is issued to the public at an expense corresponding to the cost of fresh work and coloring. My colleagues in the field to whom these labors are assigned are engaged in a laborious task, requiring judgment, skill, training, and high scientific acquirements. Theirs, no more than ours, in this museum and school, are not mere duties of routine, office, clerkship, or limited hours. There is no off-duty; the head must work whilst the eyes are open if our task is to be well and thoroughly done.

Whilst the collections here displayed are mainly confined to the mineral products of the British islands, there is one department in this building, represented at present by three or four wall-cases, that I cannot refer to without the deepest interest, insignificant though it may now seem. I allude to that of Colonial Geology. The idea of it is to exhibit the mineral products of each of our colonies separately, the evidences of their geological constitution, and the indications of their mineral wealth. Such a display would be more than a curious and interesting illustration of the products of those countries for the benefit of persons at home. It would be a source of instruction of the most vivid kind to all thoughtful men intending to emigrate,—and most emigrants are thoughtful, at least before they go. Over and over again, when working at the arrangement of the cabinets in our galleries, I have been addressed by intelligent persons of this class who have come here in the hope of meeting with a collection of the kind I have mentioned, and of passing some time in the study of it. With feelings akin to shame I have shown them our shabby though not worthless display, and endeavored to make it the text of conversation and advice. Surely it would be worthy of a great empire like ours to possess, in the metropolis of all its world-strewn states, some sufficient illustration of their structure and productions. I speak not merely of their mineral productions, which are all that we can aim at here, but of their works of art and industry, their natural productions of all kinds, and illustrations of their history and of their ethnology. It is true that many of these are embodied in general collections, and form an essential part of systematically arranged cabinets. But what we

require is to see them distinctly grouped with regard to their geography; so that, for example, the emigrant proceeding to Australia might come and learn before he departed, and the officer ordered on duty to India or the West Indies might acquire an acquaintance with the structure and products of those countries that would enable him when there to occupy his spare time in research useful to himself and beneficial to his country. All that is required for carrying out such a collection is space. Contributors anxious and able to assist would be found in numbers. Those who have derived some benefit and knowledge from their studies in the Museum before leaving, would when abroad add judiciously and gratefully to its contents. Indeed there are at present extensive and valuable collections of colonial specimens lying useless, packed in boxes, that might be had for the asking, provided it could be shown that there was a proper place in which to arrange them for the public benefit.

Museums, of themselves alone, are powerless to educate. But they can instruct the educated, and excite a desire for knowledge in the ignorant. The laborer who spends his holiday in a walk through the British Museum, cannot fail to come away with a strong and reverential sense of the extent of knowledge possessed by his fellow-men. It is not the objects themselves that he sees there and wonders at, that make the impression, so much as the order and evident science which he cannot but recognize in the manner in which they are grouped and arranged. He learns that there is a meaning and value in every object however insignificant, and that there is a way of looking at things common and rare distinct from the regarding of them as useless, useful, or curious,—the three terms of classification in favor with the ignorant. He goes home and thinks over it; and when a holiday in summer or a Sunday's afternoon in spring tempts him with his wife and little ones to walk into the fields, he finds that he has acquired a new interest in the stones, in the flowers, in the creatures of all kinds that throng around him. He can look at them with an inquiring pleasure, and talk of them to his children with a tale about things like them that he had seen ranged in order in the Museum. He has gained a new sense,—a thirst for natural knowledge, one promising to quench the thirst for beer and vicious excitement that tortured him of old. If his intellectual capacity be limited and ordinary, he will become a better citizen and happier man; if, in his brain there be dormant power, it may waken up to make him a Watt, a Stephenson, or a Miller.

It is not the ignorant only who may benefit in the way just indicated. The so-called educated are as likely to gain by a visit to a Museum, where their least cultivated faculties, those of observation, may be healthily stimulated and brought into action. The great defect of our systems of education is the neglect

in *educating* the observing powers,—a very distinct matter, be it noted, from scientific or industrial *instruction*. It is necessary to say this, since the confounding of the two is evident in many of the documents that have been published of late on these very important subjects. Many persons seem to fancy that the elements that should constitute a sound and manly education are antagonistic,—that the cultivation of taste through purely literary studies and of reasoning through logic and mathematics, one or both, is opposed to the training in the equally important matter of observation through those sciences that are descriptive and experimental. Surely this is an error; partizanship of the one or other method or rather department of mental training, to the exclusion of the rest, is a narrow-minded and cramping view from whatsoever point it be taken. Equal development and strengthening of all are required for the constitution of the complete mind, and it is full time that we should begin to do now what we ought to have done long ago. Through the teaching of some of the sections of natural history and chemistry,—the former for observations of forms, the latter of phenomena,—I cannot but think the end in view might be gained, even keeping out of sight altogether, if the teacher holds it best to do so, what are called practical applications. For this branch of education museums are the best text-books; but, in order that they should be effectively studied, require to be explained by competent teachers. Herein at present lies the main difficulty concerning the introduction of the science of observation into courses of ordinary education. A grade of teachers who should be able and willing to carry science into schools for youth has hardly yet appeared. Hitherto there have been few opportunities for their normal instruction. Now, in a great measure, this defect may be considered as removed; and in the metropolitan schools of science and art connected with the Board of Trade there are ample opportunities afforded for the acquirement of scientific knowledge in the required direction by persons who purpose to become educators.

In their instructional aspect, considered apart from their educational applications, the value of Museums must in a great measure depend on the perfection of their arrangement and the leading ideas regulating the classification of their contents. The educated youth ought, in a well-arranged museum, to be able to instruct himself in the studies of which its contents are illustrations, with facility and advantage. On the officers in charge of the institution there consequently falls a serious responsibility. It is not sufficient that they should be well versed in the department of science, antiquities, or art committed to their charge. They may be prodigies of learning, and yet utterly unfitted for their posts. They must be men mindful of the main end and purpose in view, and of the best way of communicating knowledge according to

its kind, not merely to those who are already men of science, historians, or connoisseurs, but equally to those who as yet ignorant desire to learn, or in whom it is desirable that a thirst for learning should be incited. Unfortunately museums and public collections of all kinds are too often regarded by their curators in their scientific aspect only,—as subservient to the advancement of knowledge through the medium of men of science or learning, and consequently as principally intended for the use of very few persons. This is not the main purpose for which the public money is spent on museums, though one of the very highest of their uses, and in the end of national consequence, since the surest measure of national advancement is the increase and diffusion of scientific and literary pursuits of a high grade. One of the signs of a spread of sound knowledge and intellectual tastes in a country is the abundant production of purely monographic works by its philosophers, and the evidence of their appreciation by the general mass of readers, as indicated by the facility with which they find publishers.

Very few museums present much of an industrial aspect, valuable, interesting, and popular as any arrangement or display of their contents under this point of view must evidently be. The noble invention of the Great Exhibition, a glory to the end of time around the name of one of the most enlightened princes, proved to all men the high and national interest inherent in industrial collections. It is indeed strange that amongst a people so essentially industrial in their habits, occupations, and modes of thought as the English nation, no great and comprehensive collections illustrative of their agriculture, manufactures, machinery, and sources of trade should have been formed long ago. This defect in our institutions is, however, rapidly in the course of being removed; and I need not dwell upon the value of a kind of museum, of which all sensible men now understand the importance.

It has long been a subject of discussion, in what manner and to what extent can instruction by means of lectures and public teaching be advantageously associated with public collections. There are those who are opposed to such a course, holding that museums should stand on their own exclusive merits, and be mainly places of personal study and consultation. This, however, is the contemplation of them under their scientific aspect only; and though it may fairly be maintained, that a great central collection, such as the British Museum, may be rendered most serviceable by this course of action, holding that magnificent establishment as a general index for science, and, as it were, Encyclopedia of reference,—I feel convinced, after a long and earnest consideration of the question for many years, that unless connected with systems of public teaching, museums in most instances are

of little use to the people. The most useful museums are those which are made accessory to professorial instruction, and there are many such in the country, but almost all confined to purposes of professional education, and not adapted for or open to the general public. The museums of our Universities and Colleges are, for the most part, utilized in this way, but the advantages derived from them are confined to a very limited class of persons. In this Institution, an endeavor has been made to render its contents subservient to the cause of education and instruction; and the course which is here taken may be imitated with advantage in the provinces, where there are not unfrequently collections of considerable extent turned to small account for the benefit of the residents, a large proportion of whom in many instances are ignorant of their very existence. Yet it is to the development of the provincial museums, that I believe we must look in the future for the extension of intellectual pursuits throughout the land, and therefore I venture to say a few words respecting what they are and what they should be.

When a naturalist goes from one country into another, his first inquiry is for local collections. He is anxious to see authentic and full cabinets of the productions of the region he is visiting. He wishes, moreover, if possible, to study them apart—not mingled up with general or miscellaneous collections,—and distinctly arranged with special reference to the region they illustrate. For all that concerns the whole world or the general affinities of objects he seeks the greatest national collections, such as the British Museum, the Jardin des Plantes, the Royal Museums at Berlin and Vienna. But that which relates to the particular country he is exploring, he expects to find either in a special department of the national museum, or in some separate establishment, the purpose of which is, in a scientific sense, patriotic and limited. So also with the students of history and antiquities; they are often disappointed, and in the end find what they require here and there, bit by bit, in the cabinets of private individuals. In like manner, when the inquirer goes from one province to another, from one county to another, he seeks first for local collections. In almost every town of any size or consequence he finds a public museum, but how often does he find any part of that museum devoted to the illustration of the productions of the district? The very feature which of all others would give interest and value to the collection, which would render it most useful for teaching purposes, has in most instances been omitted, or so treated as to be altogether useless.

Unfortunately not a few country museums are little better than raree-shows. They contain an incongruous accumulation of things curious or supposed to be curious, heaped together in disorderly piles, or neatly spread out with ingenious disregard of their relations. The only label attached to nine specimens out of ten is,

"Presented by Mr. or Mrs. So-and-so;" the object of the presentation having been either to cherish a glow of generous self-satisfaction in the bosom of the donor, or to get rid—under the semblance of doing a good action—of rubbish that had once been prized, but latterly had stood in the way. Curiosities from the South Seas, relics worthless in themselves, deriving their interest from association with persons or localities, a few badly stuffed quadrupeds, rather more birds, a stuffed snake, a skinned alligator, part of an Egyptian mummy, Indian gods, a case or two of shells, the bivalves usually single and the univalves decorticated, a sea urchin without its spines, a few common corals, the fruit of a double cocoa-nut, some mixed antiquities, partly local, partly Etruscan, partly Roman and Egyptian, and a case of minerals and miscellaneous fossils,—such is the inventory and about the scientific order of their contents. I have a vivid remembrance of going through the Cheetham collection at Manchester, and hearing the explanation of its contents by one of the boys on the foundation, when I was of small size myself. The peculiar classification that mystified sightseers thirty years ago is in too many instances still maintained.

There are, however, admirable exceptions to this censure. There are local collections arranged with skill and judgment in several of our county towns, and which at a glance tell us of the neighborhood and activity of a few guiding and enlightened men of science. It would be invidious to cite examples, and yet the principles, in each case distinct, adopted in the arrangement of those of Ipswich and Belfast ought especially to be noticed. In the former, thanks to the advice and activity of Professor Henslow, the specimens of various kinds, whether antiquarian, natural history, or industrial, are so arranged as to convey distinct notions of principles, practice, or history. In the Belfast Museum the eminent naturalists and antiquarians who have given celebrity to their town have made its contents at a glance explanatory of the geology, zoology, botany, and ancient history of the locality and neighboring province. The museums of Manchester, York, Scarborough and Newcastle might be cited as highly commendable likewise, thanks to the science and ability of the eminent men connected with them, or who have taken an interest in their formation. It so happens, however, that the value and excellence of almost every provincial museum depend upon the energy and earnestness of one, two, or three individuals, after whose death or retirement there invariably comes a period of decline and decay. Now this should not be, and would not be were the facilities for scientific and literary instruction in the provinces greater than they are. In very few instances do we find the collections freely open to the public. In most cases they are unassisted by local or corporate funds, and dependent entirely upon the subscriptions of private individuals. Indeed, any attempt to favor the establish-

ment of public museums and libraries through the application of local funds is opposed with a horrible vigor more worthy of a corporation among the Cannibal Islands than within the British Empire. The governing bodies of too many of our towns include no small proportion of advocates of unintellectual darkness. It is not the interest of the public but that of the publican which sways, when a councillor wiser than the rest proposes in vain to inform his fellow-citizens through the agency of free museums, libraries and gardens. This may seem a harsh and possibly a rash censure, but I speak deliberately and with knowledge of examples. And yet, alas, the direful sway of distilleries and breweries may be excused, when we learn that in some, be it hoped few instances, the proposition to establish public libraries by means of a small local rating has been opposed by the members of local so-called philosophical institutions, on the plea that having got what they wanted in this way for themselves they did not choose to pay a tax for the extension of these advantages to their less fortunate fellow-citizens.

In every museum of natural history, and probably in those devoted to other objects, there gradually, often rapidly, accumulates a store of duplicates that if displayed in the collection render it more difficult to be studied than if they were away altogether, occupying as they do valuable space and impeding the understanding of the relations and sequence of the objects classified. If, as is sometimes the case, they are rejected from the collection and stowed away in boxes or cellars, they are still in the way; for cellarage and storage—as we know here, from the want of them, to our detriment,—are indispensable for the proper conducting of the arrangements of museums. Yet out of these duplicates, more or less perfect sets of specimens might be made up, of very high value for purposes of instruction. A well-organized system of mutual interchange and assistance would be one of the most efficient means of making museums generally valuable aids to education. Much money, when money is at the command of curators or committees, is spent in purchasing what might be obtained for asking or through exchange. Some objects of great scientific interest, but equally costly, might be purchased by one establishment only, and made fully as useful, instead of being bought in duplicate by two or more contiguous institutions. The larger institutions might supply the smaller; and out of the national stores, numerous examples—to them almost worthless, but to provincial establishments highly valuable—might be contributed with facility and greatly to the public benefit.

It is in this way, viz. by the contribution of authenticated and instructive specimens, that the museums supported by the State can most legitimately assist those established from local resources in the provinces: the scientific arrangements of the latter might also be faciltated through the aid of the officers attached to Gov-

erment institutions. Money grants would do in many cases more harm than good, destructive as they are of a spirit of self-reliance, and apt to induce a looseness of expenditure and habits of extravagance.

At the same time, every shilling granted judiciously by the State for purposes of education and instruction, for the promotion of schools, libraries, and museums, is a seed that will in the end generate a rich crop of good citizens. Out of sound knowledge spring charity, loyalty, and patriotism—the love of our neighbors, the love of just authority, and the love of our country's good. In proportion as these virtues flourish, the weeds of idleness, viciousness, and crime perish. Out of sound knowledge will arise in time civilization and peace. At present it is folly and self-conceit in nations to claim to be civilized, otherwise than as contrasted with savage barbarity. The admiration of physical prowess, the honoring of tinsel and pomp, the glorification of martial renown, are yet far too deeply inrooted in the spirit of the most cultivated nations to permit of the noble epithet "civilized," being appended to their names. The nobility of industry in all its grades,—first soul work, the labor of genius—then head-work, the labor of talent,—then hand-work, the honest labor of the body striving in the cause of peace—must be honored by state and people, before either can with truthfulness claim to be civilized. We are at best as yet but enlightened barbarians. Think how all Europe and half Asia have stood for months, and are even now standing, on the verge of foul and barbarous war; how Christian nations have girded on their armor, and, with mutual distrust and well-grounded suspicion, have stood with hand on sword-hilt ready to guard or to strike; think of what is worse, of the crime and ignorance that fester in the byways of Christian cities, and then boast of civilization if you can. The arts, the sciences, taste, literature, skill, and industry seem to have thriven among us in spite of ourselves—to have come among mankind like good spirits, and by main force to have established themselves on earth. They struggle with us and conquer us for our welfare, but are not yet our rulers. Sent from Heaven, aided by the few, not by the many, they have made firm their footing. If the monarchs and presidents of the states of the earth knew wherein the best interest of themselves and their people lay, it is in these intellectual invaders they would confide. The cost of armaments and the keep of criminals would cease in time unproductively to drain their treasuries. But ambition and strife are sturdy demons yet, and the educator, who dreams of their enchainment, and anticipates the speedy approach of a peaceful millenium, has but a limited acquaintance with the condition of mankind, and the hearts of its governors.

I cannot help hoping that the time will come when every British town even of moderate size will be able to boast of possessing

public institutions for the education and instruction of its adults as well as its youthful and childish population,—when it shall have a well-organized museum, wherein collections of natural bodies shall be displayed, not with regard to show or curiosity, but according to their illustration of the analogies and affinities of organized and unorganized objects, so that the visitor may at a glance learn something of the laws of nature,—wherein the products of the surrounding district, animate and inanimate, shall be scientifically marshalled and their industrial applications carefully and suggestively illustrated,—wherein the memorials of the history of the neighboring province and the races that have peopled it shall be reverently assembled and learnedly yet popularly explained; when each town shall have a library the property of the public and freely open to the well-conducted reader of every class; when its public walks and parks (too many as yet existing only in prospect) shall be made instructors in botany and agriculture; when it shall have a gallery of its own, possibly not boasting of the most famous pictures or statutes, but nevertheless showing good examples of sound art, examples of the history and purpose of design, and, above all, the best specimens to be procured of works of genius by its own natives who have deservedly risen to fame. When that good time comes, true-hearted citizens will decorate their streets and squares with statues and memorials of the wise and worthy men and women who have adorned their province, not merely of kings, statesmen, or warriors, but of philosophers, poets, men of science, physicians, philanthropists and great workmen. How often in travelling through our beautiful country do we not feel ashamed of its towns and cities, when we seek for their ornaments and the records of their true glories and find none? How ugly is the comparison that forces itself upon our minds between the conduct of our countrymen in this respect and that of the citizens of continental towns? A traveller need not go far through the streets of most foreign cities without seeing statues or trophies of honor, serving at once as decorations and as grateful records of the illustrious men they have produced,—reminding the old of a glorious past, and inciting by example the young to add to the fame of their native soil.

My picture may seem a dream; but I have faith sufficient in England and Englishmen to believe that in the course of time it will come to pass. Had the foresight of the present crossed the imagination of an ancient Briton, he might have hoped for its realization in another world, scarcely in this. But a simple belief in the probability of State and people advancing in intellectual aims and true civilization, and working them out through the length and breadth of the land, is essentially too wholesome and compatible with the progress of Christianized human nature, not to find an embodiment in a coming reality.

Art. XXXVII.—*On the Cause of the Aurora Borealis;* by Prof. A. de la Rive.*

When in June 1836, I published in the Bibliothèque Universelle a note on the origin of hail and atmospheric electricity, I already foresaw that the same cause would explain the aurora borealis, and the irregular and diurnal variations of the magnetic needle. As I had not then seen an aurora, I withheld at that time this application of the principles. Since then I have witnessed two fine auroras, and the appearances observed, especially during that of November 17, 1848, have confirmed my view of the nature of the phenomena, while they also accord with the observations of others, especially with those of Hansteen, Bravais and Lottin, and also with the many interesting details in Humboldt's Cosmos. My subsequent electrical experiments throw additional light on the origin of the aurora.

This last statement indicates that I regard the cause as electrical. This view has often been presented before, and was brought forward by Arago at the time of Œrsted's discovery. Yet no one, to my knowledge, has explained the mode of action and production of the electricity, or the attendant phenomena resulting from this cause.

Without going into any historical details, I will briefly describe the Aurora Borealis itself and its effects, and then pass to my own theory, the accordance of which with facts I shall endeavor to point out.

1. *Description of the Aurora and its accompanying effects.*

I cite the following details principally from the Cosmos. They are derived mostly from the descriptions of Hansteen, Bravais, Lottin, and other travellers, who have been in favorable places for observing the aurora. The learned author of Cosmos has grouped the facts with great skill, presenting in an admirable manner the prominent points, and seems with scientific tact to reach towards the true theory of the phenomena which he describes.

An aurora borealis is always preceded by the formation in the horizon of a kind of nebulous veil, which rises slowly to a height of four to six or eight, or even ten degrees about the magnetic meridian; the sky though before pure, becomes darkened, and over this obscure segment, whose color varies from brown to violet, the stars are seen as through a thick haze. An arc of light, first white, and afterwards yellow, borders the dark segment. Sometimes this luminous arc is agitated for hours by a

* Mem. Soc. de Phys. et Hist. Nat. de Genève, xiii, and Bib. Univ., xxiv, 337, Dec. 1853.

sort of effervescence, and a constant change of form, before it rises into the rays or columns of light which mount to the zenith. The more intense the emission of the polar light, the brighter are the colors that appear, which from violet and bluish white pass by intermediate shades to green and purplish red—just as electric sparks are colored only when the tension is strong, and the explosion violent. Sometimes the columns of light proceeding from the luminous arc are mixed with blackish or smoky columns; sometimes they rise simultaneously from different points of the horizon; or they may unite in a sea of flames of indescribable magnificence, the form and brilliancy of which are in incessant change. The motion gives greater visibility to the phenomenon. Around the spot in the heavens towards which the dipping needle points, the rays appear to cluster and form a corona. Rarely the aurora continues till the corona is on all sides complete, and when this happens, it announces that the end of the exhibition is near at hand. The rays then become feebler, shorter, and less bright in their colors. Soon, only large nebulous motionless spots, of a pale or ashy tint, are seen over the celestial vault; and finally, traces of the dark segment in the northern horizon, where the appearances began, alone remain.

The connection between the polar light and a certain kind of cloud is recognized by all observers, who affirm, that *the polar light sends forth its brightest columns when the upper regions of the air contain masses of cirro-stratus clouds of great tenuity, which tend to form a corona around the light.* Sometimes the clouds are grouped and arranged like the auroral columns; and in this case they appear to disturb the magnetic needle. After a brilliant aurora, the trains of clouds in the morning have sometimes been found to indicate the positions of as many luminous columns during the night.

The absolute height of the aurora has been variously estimated. For a long time it was supposed that it might be ascertained by the observations of distant observers on the corona: but it is now well known that the corona is only an effect of perspective, due to the apparent convergence of rays which are parallel to the dipping needle; so that each sees his own corona, as each his own rainbow. Moreover the aspect of the phenomenon depends on the position of the observer. The seat of the aurora is in the upper regions of the atmosphere; but sometimes it appears to be produced within less elevated regions, where clouds are formed. Such observations as those of Capt. Franklin appear to establish the latter conclusion, who saw an aurora which lighted up the under surface of the clouds, whilst Mr. Kendall, two to three miles distant, saw no light whatever, although awake and constantly observing the sky. Captain Parry also as-

serts his seeing an aurora depicted on the flank of a mountain: and it is said that a luminous arc has been seen on the surface even of the sea, around the magnetic pole.

Mairan and Dalton believed the aurora borealis to be cosmical, and not atmospheric. But Biot, who had an opportunity of observing the aurora at the Shetland Isles in 1817, proved it to be an atmospheric phenomenon, from finding that it did not partake of the movement of the stars from west to east, and consequently moved with the earth's rotation. Since then, nearly all observers have come to the same conclusion; and in particular MM. Lottin and Bravais, who have observed more than 143 auroras, and given detailed descriptions of them.

It is therefore quite certain that the aurora is not extra-atmospheric. To the evidence from its appearances, we may also add the crackling noise sometimes affirmed to be heard by the inhabitants in the far north, and the sulphurous odor which also has been observed. And, in fine, if the phenomenon is wholly beyond our planet, why should it be located about the polar regions? M. de Tessan, in the voyage of the Venus around the world, saw a fine aurora australis, which he describes with care. It was 14° in height, and the centre of the arc was in the magnetic meridian. He heard no sounds connected with it, which he attributes to its distance: but he mentions that M. Verdier, a French naval officer, on the night of Oct. 13th, 1819, while on the coast of New Holland, heard distinctly a kind of crepitation, during a brilliant aurora. All the details mentioned by M. de Tessan prove the exactness of the observations.

As concomitant effects of the aurora, we have mentioned the crackling sound, and the sulphurous odor. M. Matteucci has also observed during the appearance of a late aurora, satisfactory evidence of positive electricity in the air. But of all the phenomena, those which are of most invariable occurrence are the magnetic. The magnetic needle undergoes perturbations, either to the west or east, and usually the latter. These disturbances vary in intensity, but never fail of taking place; and they are at times manifested in places where no aurora is seen. This coincidence of magnetic disturbance with the aurora, shown by Arago to be without exception, from many years of observation, enabled this philosopher to tell, while in the basement of the Paris Observatory, when there was an aurora in our hemisphere. M. Matteucci has observed this magnetic influence under a new form. During the aurora of Nov. 17, 1848, the armatures of soft iron used with the Electric Telegraph between Florence and Pisa remained attached to their electro-magnets as if strongly magnetised, although the apparatus was not in action, and the batteries out of use.

M. de Tessan cites an observation made in 1818, by M. Baral, another French naval officer, on the same coasts of New Holland, who found that he had been making a wrong course from following his needle; there had been no storm, and the compass had not been touched. But on the evening of the same day, there was a brilliant aurora, and to this he attributes the deviation—a conclusion which could not have been dictated by theory, since at the time (in 1818) the relations between electricity and magnetism were not known.

The intimate connection between the aurora and terrestrial magnetism, has led Humboldt to designate as a *magnetic storm* a succession of disturbances of equilibrium in the magnetic forces of the earth. The presence of this storm is indicated by the oscillations of the magnetic needle, and afterwards, by the aurora, of which the oscillations are precursors, and which also put an end to the storm, just as the lightning in an ordinary electric storm announces that the equilibrium, before disturbed, is again established in the normal distribution of the electricity. Humboldt finds proof, amounting to experimental certainty, in the discovery of Faraday, who produced light by the action of magnetic forces alone, that the earth, by virtue of its magnetism, has the property of emitting light quite distinct from that which is afforded by the sun.

While recognising the truth of the analogy which Humboldt here traces out, we should recollect, that it is not of itself, but because it produces electric currents, that magnetism gives out light; the light is purely electrical in origin. Magnetism produces luminous phenomena only because it can disengage electricity, and it is probably in this point of view that Humboldt says in a general way, that it is a source of light.

It is hence in electricity, and in the influence which this agent in a state of motion, and magnetism, mutually exert, that we must look for the cause of the aurora borealis. This is the view which I would sustain, and to the force of my demonstration, I propose to bring some direct experiments, as well as the results of numerous observations through past years.

2. *Proposed Theory.*

The atmosphere in its normal state is constantly charged with a considerable quantity of positive electricity, which increases as we ascend, starting at the earth's surface where it is zero.

I will not inquire into the origin of this electricity: what is certain is that its production is connected with the action of the sun, since its intensity is subject to diurnal variations. It may be a question whether the sun acts directly, either through its light or its heat, on the constituents of our atmosphere, and so produces the electricity; or whether it is an indirect effect of the

solar rays causing evaporation from the waters of the seas, or the vegetation of the land. It is probable that both causes act: yet I am inclined to regard the first as most general and most constant. But this is of little importance here: the fact of the constant charge of positive electricity in the atmosphere, and of negative electricity in the earth, is abundantly proved, and this is sufficient for our explanations.

This constant production of the two electricities must necessarily be attended by a recomposition or neutralisation; otherwise the contrary electric states would acquire an infinite tension, which is contrary to observation. This recomposition or neutralisation takes place in two ways, one irregular and accidental, the other normal and constant.

The first method is exhibited under various forms. Generally it is the simple humidity of the air, or the fall of rain or snow, which causes the neutralisation. At other times, it is the thunder-bolt, which exhibits in an energetic manner the tendency to union in the two accumulated electricities, one in the air, the other in the ground. The winds in certain cases, by mixing the air from the earth's surface which is negative like the earth, with the positive air of a region more elevated, leads to a neutralisation of the two electricities, causing either storms or an exhibition of heat lightning. In winter, the air being constantly more saturated with moisture, the direct neutralisation is effected through the aqueous vapors and there are therefore fewer great disturbances and consequently fewer storms; and at the same time, as Arago has remarked, considering the number of storms, the lightning strikes the earth more frequently in winter than in summer.

In general, the influence of the hygrometric state of the air on the manifestations of atmospheric electricity is almost as great as that of the cause itself which produces this electricity; for this influence makes itself felt both in the production of the accidental phenomena just enumerated, and in the indications of the electrometer by which we ascertain the normal electric state of the air for the hours of the day, and days of the year. Hence it is difficult to deduce from these observations even the intensity of the atmospheric electricity for any given moment, seeing that it is impossible to separate this original intensity from the degree more or less decided which the electric registers may manifest.

Let us now pass to the second mode of neutralisation of the two electricities, which I regard as normal and regular.

The positive electricity, with which the upper beds of the atmosphere are charged, will traverse them freely, because of their high state of rarefaction. But in the polar region, where the intense cold constantly condenses the aqueous vapors, it finds a

portion of the atmosphere saturated with humidity, giving rise to mists; and by this means it may easily pass to the earth and combine with the negative electricity with which the earth itself is charged. It consequently results that there are constant currents of positive electricity rising from different points of the earth's surface into the upper regions of the atmosphere, which pass towards the poles, and then return beneath the earth's surface towards each of the points whence they have started. The currents of the northern hemisphere should go to the north pole, and those of the southern, to the south pole. In the equatorial regions, the position of the sun will determine the dividing line between the two systems. We may add that the experiments made with the electric telegraph have demonstrated that the terrestrial globe is an almost perfect conductor of electricity, compensating by its mass, for what it wants in the conductibility of the materials which constitute it. Thus the existence of the currents, whose course I have traced, rests on well established principles, with a foundation of simple experiment.

But more than this: their existence is demonstrated by facts long studied and established,—those pertaining to the diurnal variation of the magnetic needle.

I do not examine here into the origin of the earth's magnetism, a subject to which I shall have occasion to return in another work; for the present, I only say that I do not regard the disturbing causes of the direction of the magnetic needle as of the same nature with those which determine this direction. I content myself now with regarding the earth as a large magnet having its two poles; and I study only the causes that modify the direction which, in this quality of a magnet, it tends to impress on the magnetic needle. These causes are the electric currents, whose existence I have just shown; they well explain the diurnal variations. These variations, in fact, consist in this, that in our hemisphere, the north pole of the needle moves to the west, during the morning until $1\frac{1}{2}^{h}$ P. M., and then returns to the east during the rest of the day, to remain stationary during the night. But this deviation is precisely that which should be occasioned by currents passing along the surface of the globe from the north pole to the equator, augmenting in intensity with the heat of the day and diminishing as it decreases. The diurnal variation is at its maximum (13′ to 16′) in those months in which the sun is longest above the horizon, May, June, July, August. It is at its minimum (4′ to 5′) during the winter months. The variation is greater as we pass from the equator towards the pole; but it is evident, that if the currents, proceeding from different points of the earth's surface heated by the sun, rise in the atmosphere to redescend at the polar regions, and thus traversing the globe, reach their point of departure, the nearer the needle to the mag-

netic pole, the greater the number of currents that will act upon it: near the equator, it will not be subject to any influence from the currents which are formed beyond the region around the needle. In winter these differences are less sensible, because the currents from the equatorial regions are the only ones whose effects will be very decided, on account of the little difference of temperature which exists in this season between the earth's surface and the upper regions of the atmosphere in the temperate and especially the polar zone.

Finally, according to our theory, the same effects should be manifested in the southern hemisphere, only that all is reversed; and this is fully established by the various results of recent observers, including those of Colonel Sabine and a large number of travellers.

I should however acknowledge that there are some anomalies, either in the hours or in the direction of diurnal variation, at certain places, especially at St. Helena and the Cape of Good Hope, anomalies which it is difficult to explain by the theory proposed. But I am convinced that when further examined, they will be found to be due to local and accidental causes, such as the vicinity of the sea, which influences very notably the diurnal variations of temperature, and especially their amplitude and the hours of the maximum and minimum of heat. The question whether there are not places of no variation, proposed by Arago, is of little importance in this connection. The points of the earth's surface without diurnal variation, will be those where the two currents originate, and whence they proceed from the right and left towards the two poles: they are situated in the equatorial regions, but they cannot well be laid down, as their position will vary with the sun, the temperature, the winds, and other disturbing causes.

But I do not dwell on this point, as my object is not to treat of the diurnal motions of the needle. My end is simply to prove from the diurnal variations, the existence of the terrestrial currents. In continuation, we may obtain another proof still more direct, although less general, of the presence of these currents, by making use of the telegraph wires for collecting them. This I have done in England, as has also Mr. Barlow; and M. Baumgartner has performed similar experiments in Germany. In these trials, the currents have in all cases been detected by means of the galvanometer. M. Baumgartner, having introduced a very sensitive galvanometer into the circuit formed by the telegraph wire between Vienna and Prague, which has a length of about 61 miles, obtained the following results when the two extremities of the wire were buried in the earth.

1. The magnetic needle never stood at zero, but was more or less deviated.

2. The deviations were of two kinds, some of large extent, even 50°, others small, varying from 1° to 8°;—the former not common, and changing in direction and intensity, so that no law can be discovered; the latter on the contrary subject to a simple law, and being very regular when the air is dry and the sky serene, but with many anomalies when the weather is cold and rainy.

Mr. Barlow has made numerous observations, and obtained results demonstrating the exactness of the principle which I have laid down. Four main lines starting from Derby, were used in his experiments, two running towards the north and northeast, and two towards the south and southwest. The direction of the currents perceived on the first two lines, was always contrary to that of the currents on the two others, as ought to be the case, on the theory proposed. But the most remarkable fact, is the perfect concordance which these observations have proved to exist between the movement of the needle of the galvanometer placed in the circuit of the telegraph wire and the diurnal variations of the magnetic needle. The diurnal movement of the needle of the galvanometer is subject to disturbances in intensity more or less continued, during storms, and also when the aurora borealis is visible; and so also is this true of the compass needle. There is this difference, that the currents acting on the latter, circulating beneath the earth's surface, should not be subject to disturbances like those which happen to the telegraph wires through the influence of the electrical condition of the atmosphere about them.

The existence then of electric currents circulating beneath the earth's surface appears to us to be well demonstrated; and once proved, it leads necessarily to the conclusion that it is a consequence of the normal and regular reëstablishment of the electric equilibrium between the earth and its atmosphere, which is broken essentially in tropical regions; whilst the electric discharges, more or less intense, which take place between the earth and the air are the accidental and variable means for the reëstablishment of this equilibrium. We may now see how the explanation of the phenomena of the aurora both north and south, flows necessarily from the formation of these electric currents circulating from the equator to the two poles in the upper regions of the atmosphere, and from the two poles to the equator along or beneath the surface of the globe.

As we have said above, the positive electricity with which the atmosphere is charged, especially in the upper regions, is carried towards the two poles either by the greater conductibility of the upper and most rarified strata of the atmosphere, or by the currents of air in the upper regions which move from the equator to the two poles. It is consequently through the vapors which are

constantly condensed in the forming mists in the polar regions that the positive electricity should find its passage into the earth, and also therefore its discharge. This discharge when possessing a certain degree of intensity should be luminous, especially if, as is almost always the case near the poles and sometimes in the upper regions of the atmosphere, it encounters in its course icy particles of extreme minuteness, which form the haze as well as the more elevated clouds.

The formation of lunar halos which generally precede the appearance of an aurora, and the fall of rain or snow which also is often a prelude to it, are a proof of the presence in the atmosphere of these fine needles of ice, and of the part they play in the phenomenon before us.

This attenuated mist, rendered luminous by the transmission of electricity, ought to appear under a regular form, like an illuminated surface of greater or less extent, and more or less broken. It should spread outward from the poles, forming as a first appearance the auroral bank like a veil in the north. The tenuity of this veil is such that the stars may be seen through it, as has been remarked by all observers. MM. Bixio and Barral, in the balloon ascension which they recently made, suddenly found themselves,—although the sky was quite serene and the atmosphere without a cloud—in the midst of a veil or mist, which was perfectly transparent, consisting of a multitude of small icy needles so fine that they were hardly visible. Such are the needles which become luminous by the passage of the electricity, which determine the formation of halos as has been rigorously demonstrated, and produce by condensation the aqueous vapors in their passage through the air towards the earth, the fall of snow or rain, or sometimes under peculiar circumstances, hail.

Now if we inquire what should pass in the portion of the luminous mist nearest to the earth's surface, we shall conclude that the vicinity of the magnetic pole must exert a decided influence on this electrised matter,—for it is in fact a true mobile conductor traversed by an electric current.

In order to obtain a correct idea of this action, I have endeavored to imitate artificially the process of nature, and with this view, I contrived the following experiment.

Into a glass globe, 30 to 40 centimeters in diameter, I introduced through one of its two opposite tubulures, a piece of soft iron wire, about 2 centimeters in diameter, making it to terminate at the inner end very near the centre of the globe, while the other end was exposed out of the globe. The wire was covered through its whole length, excepting its extremities, by a very thick insulating bed formed first of shell-lac, then with a glass tube covered itself with shell-lac, then with a second tube of glass, and finally with a bed of carefully applied wax. The

insulating layer in all was a centimeter thick, giving 4 centimeters for the thickness of the bar thus covered. Within the globe, a ring of copper surrounded the bar and its insulating bed, at the part most distant from the tubulure. This ring was arranged to be put in communication with a source of electricity exterior to that of the bar by means of a metallic wire insulated with care, which passed through the tubulure and ended without in a hook. A stopcock attached to the other tubulure of the globe, was arranged for obtaining a vacuum. When the air within is sufficiently rarified, the hook is connected with the conductor of an electric machine, and the outer extremity of the bar of iron with the soil; by this means the electricity forms within the globe a luminous sheaf, more or less irregular, which passes from the ring, and terminates at the inner extremity of the soft iron. But immediately on placing the outer extremity of the soft iron on the pole of an electro-magnet, the electric light takes a wholly different aspect. Instead of proceeding indifferently from different points of the upper surface of the cylinder of iron, it proceeds from all points in the circumference of this surface, so as to form around it a continuous luminous ring. This is not all: this ring has a movement of rotation around the magnetized cylinder, sometimes in one direction and sometimes in the other, according to the direction of the electric current, and the nature of the magnetisation. Finally, jets of brilliant light are seen to proceed from this luminous circumference, which are distinct from the rest of the mass of light. When the magnetization ceases, the luminous phenomena return to the condition familiar in the experiment, known under the name of the *Electric Egg*.

There is some advantage in using for the experiment here described Armstrong's hydro-electric machine, in which the boiler is made to communicate with the hook which is united by a metallic connection to the ring of copper within the globe, whilst the conductor which receives the vapor is put in connection with the bar of soft iron. Thus we have in the globe an electric current of great intensity which may be changed in direction, by inverting the connections.

3. *Agreement of the theory with the facts.*

We have remarked that all observers agree now in regarding the aurora as an atmospheric phenomenon, and we have cited facts in support of this view. One more fact may be alluded to here which places it beyond doubt; it is from the observations on the aurora borealis published in the History of the Voyage of Captain Franklin. Lieutenant Hood and Dr. Richardson were 55 miles miles apart for the purpose of making simultaneous observations, in order to ascertain the parallax of the phenomenon and consequently its height. The results from three trials place

it alike at a height of 6 to 7 miles. On the 2nd of April, at the most northerly station a brilliant arc was seen 10° above the horizon; at the other station, it was not visible. The 6th of August the aurora was at the zenith at one station, and 9° in height at the other. On the 7th of April it was again in the zenith at the first station, and 9° to 11° in height at the second.

Again, Hansteen, and after him, MM. Lottin and Bravais, were led to believe as a consequence of their observations, that the arc of the aurora is a luminous ring whose different parts are sensibly equidistant from the earth, and which is centered around the magnetic pole so as to cut at a right angle all the magnetic meridians which converge towards this pole. Such a ring is the auroral arch and its *apparent* summit is necessarily in the magnetic meridian of the place. M. Bravais also observes that the arc seems to have a kind of movement of rotation from the west to the east passing by the south. From this description the phenomenon is quite similar to the result of the experiment described above, and the direction of the rotation in the luminous ring is precisely that which ought to take place according to the laws governing the mutual action of currents, if it be the positive electricity which passes from the atmosphere to the surface of the earth, thence to penetrate about the north magnetic pole, reunite with the negative electricity, and thus constitute the current.

The diameter of the luminous ring will be greater, as the magnetic pole is more distant from the earth's surface, since this pole ought to be found in the intersection of the plane of the ring with the axis of the terrestrial globe.

It hence results that each observer sees the summit of the auroral arc in his own magnetic meridian; and hence only those on the same magnetic meridian see the same summit, and can take simultaneous observations for ascertaining the height.

If the summit of the arc pass the zenith of the observer, he is surrounded on all sides by the matter of the aurora, or the auroral influences which proceed from the earth, and then, if at all, the crackling sound which has been alluded to should be heard. If it does not reach the zenith, the observer is then outside of the region; and the aurora is more or less distant according to its altitude. The noise may be produced by the action of a powerful magnetic pole on luminous electric jets very near this pole, as I have proved by experiment; I have succeeded in producing a similar sound by bringing a piece of iron, strongly magnetised, to the luminous arch formed between the poles of a voltaic battery.

As to the sulphurous odor, it proceeds like that which accompanies lightning, from the conversion of the oxygen of the air into ozone by electric discharges.

The light of the aurora is not polarized, as was remarked by Biot in 1817, from his observations at the Shetland Islands. This

negative result is confirmed by Mr. Macquorn Rankine, who has shown that this absence of polarisation is not due to the feebleness of the light, since this same light viewed after reflection from water is found to be polarised by this reflection. The most careful study and experiment have found no trace of polarisation in electric light, whether the discharges be made in the air or in a vacuum. This is a new proof of the identity of these two kinds of phenomena.

Finally, we discover in the resemblance between auroral appearances and certain clouds, as well as the disturbances of the magnetic needle, a further important confirmation of our theory.

The observations of Dr. Richardson already mentioned, which show that the aurora exists at moderate elevations, also indicate that it is often connected with the formation of different kinds of *cirro-stratus* clouds. Lieutenant Hood, in speaking of the luminous bands or columns of the aurora, says that he is convinced that they are carried by the wind, because they retain exactly their relative situation, which is not the case when the luminous matter moves in the air by its own direct action. Finally, the coëxistence of the aurora with small ice needles in the atmosphere, such as exist in elevated clouds, is shown by Captain Richardson, who having seen at a temperature near $-32°$ C. ($-35°$ F.) an aurora whose superior arc was near the zenith, remarked that although the sky appeared perfectly serene during the phenomenon, there fell a fine snow hardly perceptible to the eye, though easily observed as it fell on the hand and melted. The same fact had been previously observed in full sunshine, the rays of the sun rendering the floating particles of ice visible.

Observers are agreed with regard to the existence of a stratum or dark segment, which rests in the northern horizon, and appears to be the source of the auroral display. The numerous observations of M. Struve at Dorpat, and those of M. Argelander at Abo confirm this appearance. It is like a veil, which although permitting the light to pass gives the sky a more somber aspect; moreover it is bordered by a luminous arc. The existence of such a dark segment is confirmed by an observation of Gisler, who says that in Sweden, upon the high mountains, the traveller is sometimes suddenly enveloped in a very transparent mist of a grayish white color, verging towards green, which rises from the soil, and is changed into the aurora borealis.

The cirro-cumulus and the mists become luminous when they are traversed by electric discharges sufficiently energetic, provided daylight does not efface the feeble light. They may sometimes be detected in the day: thus Arago establishes most incontestably that Dr. H. Usher was not deceived in a notice published in volume II. of the Memoirs of the Irish Academy, where he describes an aurora seen at mid-day on the 24th of May, 1788.

This observer, during the day after a night in which he had witnessed a brilliant aurora, having observed an oscillation of the stars as seen with his lens, perceived in the sky rays of a white quivering light which rose from all points in the horizon towards the pole of the dipping needle, where they formed a light and whitish corona like that which the most brilliant aurora presents at night. Arago, on consulting old records at the observatory, found that there were considerable magnetic disturbances that day in the magnetic needle kept for showing the diurnal variation, thus proving beyond question that the phenomenon observed by Dr. Usher was a veritable day aurora.

I find also in the account of the voyage of the Venus by M. de Tessan, that M. Cornulier, an intelligent officer in the French Navy, often observed on the coast of New Holland a particular direction in the cirrus clouds during the day, from which he was enabled always to announce a fine aurora australis at night. M. Cornulier, like M. Verdier, was convinced, from a study of the arrangement of the cirrus clouds, that in those regions, auroras occur during nearly every day, and that the variation is only as to their brightness; they are often hid from view by clouds and storms. This remark agrees with the observations made under the direction of Captain Lefroy in Canada, at 13 different stations, and with others, collected by the Smithsonian Institution. It results from all these observations, that the aurora was seen on almost all clear nights, when the moon was not too bright, although not at all the stations. This is especially true during the months when the nights are longest. From October to March, there is scarcely a night without a visible aurora; and they are most brilliant in the month of February. The tables show that auroras were seen during 261 nights in 1850, and 207 in 1851. It is also remarkable and natural, that the auroras should have been seen most frequently in the stations nearest the magnetic pole.

Recurring to the coëxistence of icy particles in the air with the auroras, we find striking proof on this point in the Canada observations. The tables give with exactness the weather before and after the auroras. The aurora was almost always preceded by a fall of rain or snow; it also often happened that a fall of one or the other succeeded the aurora. The appearance of lunar halos, a common prelude to auroras, is a proof of the presence in the atmosphere of these icy particles which make up the network illuminated by the electric current.

But the most important proof of the electrical origin of the aurora is that derived from its action on the magnetic needle. The observations by Arago at the observatory of Paris,* by Fors-

* Ann. de Ch. et de Phys., x. 120; xxx, 423; xxxvi, 398; xxxix, 369; xlii, 351; xlv, 403.

ter, Farquharson, and by all voyagers, establish the following conclusions:—

1. During the day preceding the night on which an aurora appears, the declination of the magnetic needle to the west is always augmented 10, 20 or 30 minutes, or more.

2. On the contrary, at the middle, and at the end of the exhibition, the needle deviates from its normal state to the east.

3. Finally, the needle often undergoes irregular perturbations during an aurora, amounting to several minutes.

It happens ordinarily that the maximum deviation of the needle during the day preceding the night of the aurora, is at noon, or half an hour after noon; and the deviation due to the disturbance may be 5 to 30 minutes or more, beyond that of the days before or following. Sometimes the maximum western deviation is at other hours in the morning, and it is probable that in such cases there is an aurora during the day. Arago cites several cases of this kind. Thus, on the 17th of August, 1828, the declination from 8½h. A. M. till noon was 5′ above the mean of the month for the same hours; and on the same day, at 10h. P. M., Messrs. Coldstream and Foggo perceived feeble traces of an aurora which was probably the end of a day aurora. During the evening the needle was in its ordinary position.

The magnetic observations made in the regions near the pole confirm the influence on the needle. Thus at Reykinwik (64° 8′ 15″ N.) MM. Lottin and Bravais, having made numerous observations on the diurnal variation of the needle parallel with similar observations at Paris and Cherbourg, were struck with the almost continual disturbance of the needle. They at first attributed it to some movement in the earth: but afterwards, remarking the concordance of their observations with those of M. de Löwenörn made in 1786, 50 years before, they satisfied themselves that the effect was due to auroras invisible to them because of the continued presence of the sun above the horizon. M. Ginge, a Danish Missionary, made observations in 1786, 1787, continued through the 24 hours, which showed that the western declination was ordinarily strongest from 9 to 10 in the evening, and least at 9 to 10 in the morning, a fact which he attributed without hesitation to the aurora. This conclusion is confirmed by the very numerous and excellent observations of MM. Lottin and Bravais.

We thus see, that for a long period observations near the pole have shown that auroras must be more frequent than was supposed, and this is confirmed by the facts observed in Canada and the United States.

We therefore conclude, that the production of auroras, northern and southern, is the normal mode of neutralising the positive electricity of the atmosphere with the negative of the earth.

This neutralisation should not take place in a manner very uniform or regular. It is evident that the variations in the mists or conducting capabilities of the atmosphere will be attended by variations in the facility of this neutralisation.

These differences will be evinced by the deviations or disturbances of the magnetic needle, which will be sensible at great distances from the poles, as in the temperate zone where they are often observed. The western deviation which in the middle latitudes usually precedes an aurora, indicates a large accumulation of electricity, due to a powerful condensation of vapors in the polar regions, which by facilitating the reunion of the two electricities, augments the intensity of the terrestrial current passing in our hemisphere from the equator to the north, and consequently carries the needle more to the west. When the aurora is once visible, the current becomes less strong, because the light itself of the aurora is proof of the resistance (probably due to the congelation of the particles of water suspended in the air that constitutes the mist) which the reunion of the two electricities encounters;* the needle will then retrograde to the east, as actually takes place.

In the higher latitudes, the disturbances of the needle are continual, because the slightest differences in the intensity of the electric discharges that take place in the polar regions should be there perceived. As to the observations of MM. Ginge, Löwenörn and Lottin, that the maximum deviation of the needle takes place from 8 to 10 o'clock in the evening, and the minimum at 9 to 10 in the morning, they were made only during some weeks in summer, and they prove only that at this season of the year, the greatest amount of condensation of moisture takes place, as should be the case, at times just preceding and following the setting of the sun, and the least 7 or 8 hours after its rising. In the observations of Lieutenant Hood, made in the voyage of Captain Franklin, between the 1st of February and the 31st of May, the greatest declination took place at 8 and 9 o'clock in the morning, and the least at an hour after noon. Thus, as is seen, the times of the maxima and minima are widely variable in those high latitudes, where there are great differences in the length of the day, and also in temperature, and therefore considerable electric disturbances of the air.

It is a singular fact, sometimes noticed, that when an observer is in the midst of an aurora, so to speak, the action on the needle may be null. This was remarked by Mr. Forster, at Port Bowen, beyond 65° N., the latitude of Forts Franklin and Enterprise, where Dr. Richardson had on the contrary observed the action of the needle. In fact, a needle in the interior of the circle formed by

* It is clear that the mist when first formed should be a better conductor than when, afterwards, it consists only of icy particles.

the aurora about the magnetic pole, is no longer under the influence of the currents which circulate around it and not above or below, and it ought therefore to experience only a variable and irregular action.

I have said that the aurora was probably of daily occurrence, and varied only in intensity. These differences in intensity are the reason for its being not always perceptible, and also for its less frequency remote from the magnetic poles. As to the differences of number for each month, they are attributable to two causes—but especially to the unequal length of the nights, for there should be fewer in the shorter nights. Thus in May, June and July the fewest are seen, because the days are the longest, while in the nine others, and especially in March, September and October, they are most numerous. This preëminence of these three months above others of still shorter days, can be due only to this, that the auroras are most frequent at the times of the equinoxes, and especially the autumnal equinox. This is readily understood if we consider that the vernal equinox is the time when the sun transfers to the northern hemisphere its powerful influence either direct or indirect in the development of electricity; and that the autumnal should be followed with a large condensation of the vapors accumulated in the atmosphere during the months of summer—a condensation which, as already explained, facilitates the neutralisation of the two electricities, developed in large quantities during the summer, and augments consequently the intensity of the discharge at the pole.

It has been pretended that in the appearances of the aurora borealis there are secular variations; in other words, that there are epochs comprising a certain number of years during which auroras are particularly frequent, and others in which they are rare. This opinion does not appear to me to be based on documents sufficiently exact to be admitted. There may be a difference in different years, as there is a difference in temperature and humidity. But this is far from making out a periodicity in auroras: to establish such a periodicity, there ought to be the collected observations of a century, from observers at least as good, and as favorably situated with reference to the magnetic poles, as those now engaged: and this we have not. We need not therefore dwell longer on this point, only remarking that if really such a periodicity exists, it might be connected with the change in the magnetic poles, which are the centers of the aurora, and which according to the surface about them would more or less facilitate the electric circulation: for it is evident that the naked soil would afford more ready circulation than a surface covered with a great thickness of ice. But, I repeat it, the fact of the periodicity is far from proved.

Recapitulation.—1. All observations agree in demonstrating that the aurora borealis is a phenomenon taking place in our atmosphere, and that it consists in the production of a luminous ring whose center is the magnetic pole, and having a diameter more or less large.

2. Experiment demonstrates that in causing in highly rarified air the reunion of the two electricities near the pole of an artificial magnet, a small ring of light is produced similar to that which constitutes the aurora, and having a like movement of rotation.

3. The aurora is consequently due to electric discharges taking place in the upper regions between the positive electricity of the atmosphere and the negative electricity of the earth—the electricities being separated by the direct or indirect action of the sun, principally in the equatorial regions.

4. As these electric discharges take place constantly, though with varying intensity, depending on the state of the atmosphere, the aurora should be a daily phenomenon, more or less intense, and consequently visible at greater or less distances, and only when the night is clear—which accords precisely with observation.

5. The phenomena that attend the aurora, such as the presence and form of the cirro-stratus clouds, and especially the disturbances of the magnetic needle, are of a kind to demonstrate the truth of the electric origin attributed by the author to the aurora—an hypothesis with which these phenomena correspond even in their minutest details.

6. The aurora australis, according to the few observations on it which have been made, presents exactly the same phenomena as the aurora borealis, and is explained in the same manner.

ART. XXXVIII.—*Notice of three ponderous masses of Meteoric Iron at Tuczon, Sonora;* by CHARLES UPHAM SHEPARD, M.D.

THE first intimation concerning the locality here noticed, was afforded in 1851, at the Meeting of the American Association for the Advancement of Science, on the occasion of my describing before the Chemical and Natural History section of that body, the meteoric stone of Deal, New Jersey. Dr. J. L. LeConte being present, and having just returned from California through the province of Sonora, stated to the meeting, that "while passing through the village of Tuczon, a frontier town of Sonora, near the Gila, in the month of February previous, he observed two large pieces of meteoric iron, which were used by the blacksmiths of the town for the purposes of anvils. He was unable to procure any specimens from these bodies; but was guided to a cañon

between two mountain ridges in the immediate vicinity from which both pieces had been taken, where the masses of meteorites were so abundant as to have given name to the cañon. He had not before heard any account of this remarkable circumstance, and had considered it an interesting subject for observation."*

Nothing farther was brought to light respecting this very remarkable locality, until the present season, on the return of Lieut. John G. Parke, of the United States Topographical Engineers, from his scientific explorations in Sonora, when he had the goodness to address me a letter of inquiry respecting them, attended with about an ounce weight for my examination, which he had procured in person from one of the masses.

Lieut. Parke observed in his letter that "the Alcaide and Commandante would not consent to our removing the masses, even had we possessed the means; but by dint of two hours hard labor, we managed to chip off a few fragments, which I hope may serve the purposes of analysis."

I immediately set myself to the best examination of the subject, which the limited supply of materials and the facilities at hand, permitted.

The fragments were small; the largest piece not weighing above one-quarter of an ounce, and that somewhat battered by the process employed for its separation. Still, it showed the natural outside of the meteor. It was destitute of a well marked crust, and much coated with oxyd of iron, evincing in common with the other fragments, that this iron is prone to undergo a rapid oxydation on exposure to the weather.

The fresh surfaces presented the color and lustre of white cast-iron; though it is not brittle, or granular in its fracture. A close examination of a fresh surface, produced by the cold chisel, reveals frequent white spots, of the size of a pin's head and smaller, scattered in every direction, and without any very perceptible order. These spots seem to be owing to the presence of an earthy powder, which adheres closely to the iron, and indeed seems partially imbedded therein. When such a surface is highly polished on the burnishing wheel, the spots disappear; but are renewed again on the application of acids, in the etching process. They then come into view, rather more circumscribed in their areas than before; but of a very determinate figure, being mostly rounded or oval, sometimes with angular indentations in their borders. They are never rhomboidal or rectangular in their outline, after the manner of the much larger earthy grains, or crystals, in the Atacama iron, which render the latter porphyritic, when cut into slabs. The Tuczon iron on the contrary, when thus polished and etched, is amygdaloidal only; and to discern this character thoroughly, requires the aid of a microscope.

* Proceedings of the American Association for the Advancement of Science, Sixth Meeting, p. 188.

The acids act very tardily on the iron, and require to be aided by heat, before the action will fairly commence. No decided crystalline structure is developed in the process; though the fragments experimented on, being small, and considerably altered in molecular texture by the force applied in their separation from the parent mass, it would not be safe from this trial perhaps, to conclude against a crystalline structure in the main portion of the iron.

Sp. gr. = 6·66, which corresponds very nearly with that of the Atacama iron, as determined by Turner, whose trial specimen no doubt included the earthy constituent of that iron.

No sulphur was detected in those fragments that were acted upon by acids; but here again, it would not be strange if this very common element of meteorites should hereafter be detected, when a larger portion of the mass comes to be examined.

The most striking phenomenon that presented itself during my examination of the Tuczon iron, was the following. A white, insoluble powder came into view throughout the liquid, as the solution of the iron proceeded in nitro-hydrochloric acid; and at the conclusion of the process a considerable precipitate of this powder was obtained, among which were little ovoidal grains of a milk-white mineral and occasionally also, others of the same figure that were perfectly limpid, like hyalite; while others still were milky on one side and limpid on the other,—thus evincing that the milky and the limpid mineral, was one and the same species. Indeed I was led to regard the mealy powder also, as partaking of the same nature; and such was the general resemblance of the whole, to the mineral I have called chladnite, in the meteoric stone of Bishopsville, South Carolina, that I am led to refer this earthy substance to that species: an opinion which is the more probably correct, as I found the acid solution to contain decided traces of magnesia, an earth which it is most likely proceeded from the partial decomposition of portions of the pulverulent, earthy ingredient of the meteoric iron, and not from the iron-alloy. Should this view of the unknown substance prove correct, it will be the first instance in which it has been found in an iron-mass. We shall then have (astropetrologically considered) a second species of meteoric iron, with an earthy admixture; the first being the previously known *peridotic iron*, and the second, that here pointed out, viz., the *chladnitic iron*.

The nitro-hydrochloric solution of the iron, afforded with ammonia in excess, a deep blue liquid, indicative of nickel in a very decided proportion, to the iron.

It remains only to state a few additional particulars concerning these iron-masses, derived from a later letter of Lieut. Parke, which he kindly permits me to annex to this notice.

"The three masses were found in a cañada of the Santa Rita Mountain, about 25 or 30 miles to the south of Tuczon. Two of them were shown to us by the Commandante; both being

used as anvils. One lies within the Presidio, and is of a very peculiar form, it being annular, and somewhat like a seal-ring of huge proportions. Its exterior diameter is about three and a half feet; its interior about two. It weighs nearly 1200 lbs. The other piece is in front of the Alcalde's house. It weighs about 1000 pounds, and has an elongated prismatic form, serving well the purposes of an anvil. It is partially buried in the soil, but having two feet of its length projecting above the ground. The third piece I did not see; but was told that it was much smaller than either of the others. By permission of the authorities, our blacksmith undertook to cut off some specimens, in which, however, he almost entirely failed—the metal being so tough and hard. It yields to the hammer, and has a clear ring, not unlike that of bell-metal. The surfaces were rounded, and rusted,—closely resembling a mass of refined cast-iron that had been exposed to the action of the weather for a long period. The surfaces that have received the blows of the hammer, where used as an anvil, are quite polished.

"To obtain these specimens would be attended with no little difficulty, owing to the remoteness of the locality, and the broken-down condition of animals when reaching this point."

The route of transportation recommended by Lieut. Parke, is that, via. Fort Yuma, distant 275 miles from the locality, on the California side; and from thence by water, to the head of the Gulf of California. Measures are already on foot for the removal of one or more of the masses, to this part of the country, which it is greatly to be desired will be crowned with success.*

ART. XXXIX.—*Reëxamination of American Minerals:* PART IV—*Boltonite; Iodid of Silver; Copiapite; Owenite; Xenotime; Lanthanite; Manganese Alum; Apophyllite; Schreibersite; Protosulphuret of Iron; Cuban;* by J. LAWRENCE SMITH, M.D., Prof. Chem. Med. Depart. University of Louisville.†

37. *Boltonite, identical with Chrysolite.*

BOLTONITE was first described as a new species by Professor C. U. Shepard. He made the specific gravity from 2·8 to 2·9. It was subsequently examined by Professor Silliman, Jr., who found

* The above Sonora meteoric irons were described and illustrated with figures in a paper by Dr. J. Lawrence Smith, presented to the American Association at its meeting at Washington in April last—a paper which was to have appeared in our last number, but is still delayed. The masses were seen by officers of the late Boundary Commission, and figures are published in Bartlett's Personal Narrative (8vo, 1854), ii, 298.—EDS.

† The absence of Mr. G. J. Brush from America, who was associated with me in the first three parts of these reëxaminations, makes it necessary for me to continue them alone and the absence of his valuable assistance is a matter to be regretted by all who take any interest in the subject.—J. L. S.

3·008 as its specific gravity, with a hardness of from 5 to 6: his analysis gave for its constituents:*

Silica,	46·062
Alumina,	5·667
Magnesia,	38·149
Protoxyd of iron,	8·632
Lime,	1·516

With this knowledge of the mineral, I undertook its examination, on specimens in the gangue furnished me by Prof. Shepard. Examination of different portions separated mechanically from the gangue, made it very evident that the mineral was more or less mixed with other substances which had escaped observation, for no two analyses agreed; and it was soon discovered that it was impossible (from the specimens in my possession at least) to separate Boltonite in a state of purity without the aid of other means than had been adopted.

Boltonite, as is well known, occurs at Bolton, Mass., disseminated in irregular masses and grains in a white limestone. If a piece of the mineral in its gangue be placed in cold dilute hydrochloric acid, the limestone is readily dissolved, and a mass left, which is seen to consist of asbestus, dolomite, a little mica, small crystals of magnetic iron, and a greenish or yellowish green mineral; if the acid be now heated, the dolomite will be entirely dissolved with a little of the last mentioned mineral.

In order to obtain the Boltonite as pure as possible for analysis, the following method was adopted. Pieces were separated by the hammer as thoroughly as possible from all other substances; these were subsequently placed in dilute hydrochloric acid, and boiled for some time; the acid being washed away and the substance dried, it was crushed in a mortar to fragments from the twentieth to the tenth of an inch in diameter; these were again introduced into dilute acid and heated for a short while; the acid was thoroughly washed away, and the mineral dried. The small fragments (now like coarse gravel) were placed on a piece of glazed paper, the hand laid flat upon it and the mineral rubbed so as to grind the particles against each other for the purpose of ridding their surfaces of a little cohering silica arising from its partial decomposition; with a small gauze sieve the finer particles are separated, and from that remaining in the sieve we are enabled with the aid of a glass without any difficulty to pick out the pure Boltonite. This method requires a little patience, but no extraordinary care, and however unpromising the original specimens may have been, there is no difficulty in obtaining a material, the results of whose analysis is constant. From a larger selection of specimens than that used, there doubtless could be obtained pieces perfectly pure of some size. After being satisfied with this method of obtaining the pure mineral, three different portions were pre-

* This Journal, vol. viii, 2d ser., p. 391.

pared and examined, the first two being of the greenish variety and the third of the yellow variety, which color is doubtless due to a peroxydation of a minute quantity of the protoxyd of iron entering into the constitution of the mineral. Mr. L. Saemann in a communication made to the American Association some time since, attributed this change to magnetic iron undergoing decomposition; but this, however, does not appear to me to be the case, for the reasons that crystallized magnetic iron is a mineral difficult of decomposition, and the color is not in fissures as would be the case if the peroxyd arose from a substance foreign to the composition of the mineral, but enters into its most intimate structure.

The hardness of Boltonite is found to be, as already stated, between 5 and 6. The specific gravity was taken on three specimens; Nos. 1 and 2, on a gramme each of fine particles; No. 3 on a piece of ·150 gramme, all possible precautions being used to arrive at correct results:

No. 1, 3·270 No. 2, 3·208 No. 3, 3·328

No. 3 is to be regarded as by far the most reliable, as in taking the sp. gr. of fine grains it is almost impossible to detach the last particles of air, and consequently the sp. gr. they indicate is below the true number.

The analyses of three portions gave—

	No. 1.	No. 2.	No. 3.
Silica,	42·56	41·95	42·41
Magnesia,	51·77	51·64	50·06
Protox. iron,	2·35	3·20	} 3·59
Alumina,	0·10	0·25	}
Loss by heat,	2·22	1·58	not estimated.
	99·00	98·62	

Nos. 1 and 2 were the greenish variety, No. 3 the yellowish. The oxygen ratio of the silica and protoxyds are—

	No. 1.	No. 2.	No. 3.
Silica,	22·11	21·77	22·03
Magnesia,	20·35	20·30	19·67
Protoxyd of iron,	·52	·71	·75

This being as one to one within a small fraction, the formula therefore is $(\dot{M}g\ \dot{F}e)^3\ \ddot{S}i$, or of the general form $\dot{R}^3\ \ddot{S}i$, which of course proves it to be *chrysolite*, a fact sustained in every respect by its physical characters.

38. *Iodid of Silver.*

In this reëxamination of American minerals it was not originally designed to include those of South America: but my recent examination of the minerals obtained by Lieut. Gilliss of the U. S. Chili Expedition, has afforded an opportunity of analyzing certain minerals that it was well to investigate, and among these

were one or two fine specimens of iodid of silver. A reëxamination of this mineral is especially interesting, from the fact that its composition is still in doubt, owing to the discrepancy between the original analysis of Vauquelin on the mineral from Zacatecas in Mexico, and that of Domeyko on the mineral from Chanarcillo in Chili.

	Vauquelin.		Domeyko.	
Iodine,	22·6	$Ag^2 I$	46·89	Ag I
Silver,	77·4		54·25	

The constitution of the native Chlorids and Bromids of Silver would lead to the supposition that Domeyko's analysis was the correct one, and this is strengthened by its resemblance to the artificial iodid of silver.

The specific gravity was found to be 5·366, being a little lower than that given by M. Domeyko. The analysis of an exceedingly pure specimen gave me—

	1.	2.
Iodine,	52·934	53·109
Silver,	46·521	46·380
Chlorine,	*trace*	*trace*
Copper,	*trace*	*trace*
	99·455	99·489

clearly showing its constitution to be

Ag I = Iodine 53·85, Silver 46·15 = 100,

leaving no doubt of its perfect analogy to the natural chlorid and bromid of silver. The other properties of this mineral are not mentioned, as they are all fully stated in all works on mineralogy.

39. *Copiapite.*

This mineral was also furnished me by Lieut. Gilliss, it having been brought from Chili. It consists of most beautiful silky fibres or fibrous masses of a pearly lustre. Its color is white with a very slight tinge of yellow. From the specimens in my possession there was no difficulty in picking out a portion in a state of great purity. Its specific gravity is 1·84. Examined under the microscope its form appears to be a hexagonal prism. Cold water has but little action on it, merely causing the crystals to separate and the mass to swell out to a very much increased bulk. If the water be boiled, decomposition ensues with a deposition of the oxyd of iron and the formation of a soluble sulphate. On analysis it afforded

	1.	2.
Sulphuric acid,	30·25	30·42
Peroxyd of iron,	31·75	30·98
Water,	38·20	not estimated.
Undissolved,	0·54	
	100·74	

The analyses correspond to the formula

$$\dot{F}e\,\ddot{S}^3 + 11\dot{H}.$$

This is the same formula as that obtained by Rose, with an additional half atom of water, his formula being

$$2\dot{F}e\,\ddot{S}^2 + 2\dot{H}.$$

Protoxyd of iron was looked for but none found.

40. *Owenite,* identical with Thuringite—with an announcement of a new locality.*

Owenite was first described by Dr. F. A. Genth as a distinct species, who gave a minute and accurate analysis in the Am. Journ. of Science, vol. xvi, 2d series, p. 167. It was found on both sides of the Potomac river near Harper's Ferry. The physical characters being already fully and accurately given, it is needless to repeat them here, merely remarking that its specific gravity as taken by me is 3·191. It is readily soluble in hydrochloric acid; notwithstanding, analysis No. 2 was made by fusion with carbonate of soda. Results of analyses as follows:

	1.	2.	Genth.
Silica,	23·58	23·52	23·21
Peroxyd of iron,	14·33		13·89
Alumina,	16·85	16·08	15·59
Protoxyd of iron,	33·20	32·18	34·58
Protoxyd of manganese,	0·09		*trace*
Magnesia,	1·52	1·68	1·26
Lime,	—		0·36
Soda,	0·46		0·41
Potash,	*trace.*		0·08
Water,	10·45	10·48	10·69
	100·50		99·97

After this examination it was rendered strongly probable that Owenite and Thuringite were similar if not identical minerals; yet, in the analysis of Thuringite by Rammelsberg, alumina is not mentioned as one of its constituents. This view was sustained by the apparently perfect accordance in the physical characters of the two minerals, coupled with the fact that the amount of silica and water in the two, as already examined, was the same, and also the sum of the oxyds of iron and alumina in the Owenite were equal to the sum of the oxyds of iron in the Thuringite. To settle the question, it became necessary to reëxamine Thuringite, of which I obtained a specimen from Mr. Markoe, coming from the original locality; it was slightly altered by the action of the air, but this could interfere only with the correct estimate of the protoxyd of iron. Its specific gravity was 3·186, and its composition,

* The identity of these two minerals has already been announced by me in a letter to one of the editors of this Journal (Am. Jour., xvii, 131), but no details were then given.

Silica,	22·05
Peroxyd of iron,	17·66
Alumina,	16·40
Protoxyd of iron,	30·78
Magnesia,	0·89
Soda, Potash,	0·14
Water,	11·44
	99·36

The peroxyd of iron is a little higher, and the protoxyd a little lower than in the analysis of Owenite, but this arose from the partial decomposition of the specimen. The correct analysis of Thuringite is that first given, and the formula deduced by Mr. Genth from it is to be looked upon as the correct one, namely—

$$2\dot{R}^3\ddot{S}i + \ddot{R}^3\ddot{S}i + 6\dot{H},$$

corresponding to the oxygen ratio for

$$\dot{R}, \dot{H}, \ddot{S}i, \dot{H}, \quad 1 : 1{\cdot}5 : 1{\cdot}5 : 1.$$

In looking over some minerals placed in my hands by Mr. Markoe, I have found a specimen of Thuringite coming from the Hot Springs of Arkansas. Its identity is made out without the slightest difficulty, as all its physical characters correspond most perfectly with the Thuringite, its sp. gr. being 3·184 and composition—

Silica,	23·70
Peroxyd of iron,	12·13
Alumina,	16·54
Protoxyd of iron,	33·14
Magnesia,	1·85
Manganese,	1·16
Soda, Potash,	0·32
Water,	10·90
	99·74

An interesting fact connected with this mineral as shown by this investigation is, that although not crystalline, or at least very obscurely so, yet coming as it does from three localities so widely separated as Thuringia, the Potomac, and Arkansas, it is nevertheless found quite unmixed with any other mineral, as the analyses indicate.

41. *Xenotime of Georgia.*

In examining a few years ago some of the residue of gold washings from Clarksville, Georgia, in the possession of Prof. Gibbes of Charleston, I observed some small octahedral crystals associated with zircon, titaniferous iron and kyanite. Two or three of the most perfect were selected, and having no goniometer at hand, they were sent to Mr. Teschemacher, who referred them, after a partial examination, to Zircon. Prof. Gibbes subsequently examined their form, and pronounced them Xenotime, (Am. Jour. Science, 2nd Ser., xiii, 143). Since then, from ma-

terial that had been placed in my hands by that gentleman, nearly a gramme of the substance has been procured, and upon that the following examination has been made.

Some of the crystals are exceedingly short prisms surmounted by four-sided pyramids, but most of them are without the prism, the summits coming together forming a flattened octahedron. The measurements made were: over the pyramidal edge 123° 10′, over basal 81° 30′, face of pyramid on prism 131° 40′. The above measurements can be made with perfect accuracy; not so the faces of the prisms on each other, and as far as I could make it out, I am inclined to think that they are not square prisms, but rhombic prisms of 93°. Its hardness is 4·5, sp. gr. 4·54, and the physical characters those given for Xenotime.

It was decomposed by fusion with carbonate of soda and silica, and analysed with the following results:

Phosphoric acid,	32·45
Yttria,	54·13
Oxyd of Cerium, (with a little La and D)	11·03
Oxyd of iron,	2·06
Silica,	0·89
	100·56

This analysis will be seen to differ from that of the Xenotime of Hitteroe, Sweden, by Berzelius, in that a portion of the yttria is replaced by the oxyd of cerium; the formula represented by the analysis is, however, the same, namely,

$$(\dot{Y}, \dot{C}a)^3 \ddot{P}$$

Great care was taken in the separation of the oxyd of cerium, which after being peroxydized by heat, yielded but little to dilute nitric acid, indicative of the presence of but a small quantity of the oxyds of lanthanum and didymium.

42. *Lanthanite.*

This mineral was first observed in America by Mr. W. P. Blake, and described in this Journal, Sept. 1853; it was obtained by Mr. Blake from Bethlehem, Lehigh Co., Pa., where only one specimen had been found. It was handed to me for examination, and ascertained to be carbonate of lanthanum; the analysis made was given in the original description of the mineral. Since then I have made another analysis on a portion remaining in my possession, and although not differing from the former one, it is thought proper to insert it in this paper.

	1.	2.
Water,	24·21	24·09
Carbonic acid,	21·95	22·58
Protoxyd of Lanthanum (with some oxyd of Didymium),	55·03	54·90
	101·19	101·57

No. 2 is the analysis already published in the paper before mentioned. In both instances, there was an excess, owing to the peroxydation of a portion of the lanthanum,—a circumstance that cannot be avoided, nor do we know how to allow for it in our calculation. This mineral has the same formula as the artificial carbonate, namely, $La\,\dot{C}+3\dot{H}$ = Carbonic acid 21·11, oxyd of lanthanum 52·94, water 25·95.

The only other known locality of this mineral is Bastnäs in Sweden; it is there found only as a coating to Cerite, and doubtless was not obtained in a perfectly pure state by Hisinger, who gave as its formula, $La^3\,\dot{C}+3\dot{H}$. I have no doubt as to the minerals being identical, and that whenever the Bastnäs variety is obtained crystallized, it will prove to have the same composition as the Bethlehem variety.

43. *Mangano-magnesian Alum from Utah.*

This alum was observed a few years ago by Dr. Gale, among specimens brought from the Salt Lake, in Utah, by Mr. Stansbury. It occurs at a place called Alum Point, and was considered altogether a manganese alum, of which Dr. Gale gave what he then stated he considered an imperfect analysis (Am. Journal Science, vol. xv, 2nd ser., 434):

$\ddot{S}$ 18·0 $\dot{M}n$ 8·9 $\ddot{A}l$ 4·0 $\dot{H}$ 73·0

Being desirous of having it more carefully analyzed, Dr. Gale placed in my hands the specimen which is the subject of the present investigation. It was not received as it occurs at the locality, but had been recrystallized and consisted of delicate needle-shaped crystals, adhering in small masses. It dissolves very readily in water; in fact so soluble is it that it is difficult to decide the amount of water requisite for its complete solution. It crystallizes from solution in the form of delicate crystals, with a plumose aggregation. On analysis it furnished:

Alumina,	10·40	10·65
Magnesia,	5·94	5·65
Manganese,	2·12	2·41
Sulphuric acid,	35·85	35·92
Oxyd of iron,	0·15	0·09
Potash,	0·20	0·20
Water,	46·00	46·75
	100·66	101·67

This analysis shows an amount of protoxyds a little too high for the requisites of the formula of alum, but this however, is of frequent occurrence in the natural alums, owing to admixture of impurities. This variety of alum has been before observed by Stromeyer, and was brought from a cave in Southern Africa. Its formula is,

$$(\dot{M}g, \dot{M}n)\,\ddot{S} + \ddot{A}l\,\ddot{S}^3 + 24\dot{H}.$$

44. *Apophyllite.*

The specimen of this mineral examined, came from Lake Superior. It is eminently lamellar in its structure, and was placed in my hands as being possibly diaspore; its lustre is however much more pearly than this latter mineral. Its sp. grav. is 2·37, and its constitution,

Silica,	52·08
Lime,	25·30
Potash,	4·93
Fluor,	0·96
Water,	15·92
	99·19

45. *Schreibersite (of Patera).*

This meteoric mineral occurs in the American meteorites in more abundance than has usually been supposed, as was fully shown in a communication made to the Am. Assoc. for the Advancement of Science in April, 1854; and as that memoir will be published in full in this Journal, nothing farther than the mere statement of the analysis of this mineral is here given. G. = 7·017.

	1.	2.	3.
Iron,	57·22	56·04	56·53
Nickel,	25·82	26·43	28·02
Cobalt,	0·32	0·41	0·28
Copper,	*trace*, not estimated.		
Phosphorus,	13·92		14·86
Silica,	1·62		
Alumina,	1·63		
Lime,	*trace* not estima'd	not estimated.	
Chlorine,	0·13		
	100·66		99·69

Nos. 1 and 2 were separated mechanically from the meteoric iron; No. 3 chemically. The silica, alumina and lime, were almost entirely absent from No. 3; and in the other specimen it is due to a siliceous mineral that I have found attached in small particles to the Schreibersite, and of which I have preserved one or two small specimens.

The formula of Schreibersite I consider to be $Ni^2 Fe^4 P$.

		Pr. ct.
Phosphorus,	1 atom,	15·47
Nickel,	2 "	29·17
Iron,	4 "	55·36

Further particulars of this mineral will be found in the paper already referred to.

46. *Protosulphuret of Iron.*

This sulphuret is the one found in the meteoric irons of this country. The specimen examined came from Tennessee; its sp. gr. is 4·75. Its composition is different from that of magnetic

pyrites, although some authors consider the magnetic pyrites a protosulphuret, an inference not sustained by analysis. The mineral in question afforded me

Iron,	62·38
Sulphur,	35·67
Nickel,	0·32
Copper,	*trace*
Silica,	0·56
Lime,	0·08
	98·91

The formula Fe S requires Sulphur 36·36, Iron 63·64 = 100.

Further remarks on this mineral will be found in the paper on meteorites.

47. *Cuban.*

This variety of copper pyrites was first noticed by Breithaupt, as occurring among the copper ores of Cuba. Desiring to reëxamine it, specimens were obtained from Prof. Booth; they were massive and not perfectly pure, furnishing an insoluble residue consisting of silica and oxyd of iron which are very probably combined. Its sp. grav. was 4·180, and its composition—

	1.	2.	3.
Iron,	37·10		
Copper,	18·23	19·10	19·00
Sulphur,	39·57	39·20	39·30
Residue (silica and oxyd of iron),	4·23		
	99·13		

This seems to substantiate the formula already received, (agreeing with the analyses of Prof. Booth,) $Cu\,S + Fe^2\,S^3$, pyrites being $Cu^2\,S + Fe^2\,S^3$ = Sulphur 42·28, Copper 20·82, Iron 36·90.

ART. XL.—*Correspondence of M. Jerome Nicklès, dated Paris, June* 28, 1854.

Academy of Sciences.—For some days, the Academy has been occupied repairing the loss experienced at the beginning of the year. In place of Dr. Roux, Dr. Claude Bernard has been named, well known for his discoveries in Physiology: in place of Admiral Roussin, an officer of the navy, M. Bravais, an admiral in science, although but a lieutenant in his official capacity. The labors of M. Bravais have not been confined to navigation and hydrography. He has published important mathematical works; his researches on halos, auroras, mirage, the rainbow, parhelia, and meteorology in general, have given him a prominent name in Physics, while his works on the arrangement of leaves on branches, the symmetry of inflorescence, the laws of growth of the Pinus sylvestris, have made him known to naturalists.

On the Phenomenon called "Spirit-rappings."—The time not occupied by the discussion of the titles of candidates, has been filled with communications, some of them of interest. The question also of "table-turnings," and "spirit-rappers," has engaged the attention of a physiologist of Francfort, Dr. Schiff, who has given in a full session, a demonstration showing that the noise of the "spirit-rappers" is not the result of a stroke of any part of the body on an external object; but that it is produced by means of the great peroneus muscle, the tendon of which passes behind the external malleolus, to which it is usually retained by a ligament. When this ligament fails, or when it is much relaxed, if the muscle is suddenly shortened, the tension of the tendon becomes so great that it slips suddenly from the malleolus, producing a noise similar to that of a stretched cord suddenly loosened.* M. Schiff by practice has become able to make these sounds at will; and he has given proof of it before the Academy: seated in a semi-circle, and in profound silence, they heard him produce the described sound for more than a minute. Restored from their surprise, the Academy hastened to change the subject, as if ashamed to occupy itself with the scientific explanation of a fact which for some time has occupied the popular imagination.

Electricity—*Electro-chemical action.*—Works on Electricity have specially occupied the attention of physicists in France. M. Becquerel, Sr., the inventor of the constant battery, and who was the first to form minerals by means of electricity, notwithstanding his advanced age, works with the activity of his youth. One of the ideas which constantly urges him onward in new efforts at progress, is the conviction that we have yet disengaged only a feeble part of the electricity which is associated with the molecules of matter, because of the recomposition which takes place through the contact of bodies. It is precisely a cause of this kind which interferes with the constancy of the batteries employed for chemical purposes. Plates of platinum used as electrodes become covered with gas, and take polarity; and consequently they give origin to contrary currents which necessarily diminish the effect of the pile. To avoid such disturbing causes, M. Becquerel has contrived two pieces of apparatus for constantly depolarizing the electrodes, making them at every moment to change their polarity. The author has exhibited his apparatus in action before the Academy, and has since applied it to the study of the principle which governs the disengagement of electricity in chemical action, a principle which he first brought out in 1823, and which since has been adopted in the science.

* Dr. Austin Flint of Buffalo, at the commencement of the "spirit-rapper" delusion, exposed the source of this noise in the same way precisely as Dr. Schiff.—Eds.

His depolarising apparatus gives him a more constant current than had been obtained, and serves as a means of verifying the results he before arrived at, which are for the most part confirmed. The following are his conclusions:

1. In the action of acids on metals, or on saline solutions, the acids or acid solutions take always an excess of positive electricity; the metals and alkaline solutions, a corresponding excess of negative electricity.

2. The disengagement of electricity in combustion is governed by the same principle; the combustible body disengages negative electricity, the supporter of combustion, positive.

3. Decompositions produce inverse electric effects.

4. There is no disengagement of electricity as long as the two bodies in hand are conductors of electricity: thus in the combination of a metal with oxygen, iodine, or dry bromine, electricity is not produced.

5. In the mixture of acids with water, or in their combination with it, water acts as a base; whilst it acts as an acid, as regards alkaline solutions.

6. Concentrated solutions of a neutral salt act with reference to water, as regards electrical effects produced, in the same manner as acids with reference to bases.

7. Acids in their combination or their mixture with other acids act in such a way that the acids the most oxydising are the most electro-positive; in their combinations with bases, the acids appear to retain the same property, so that in the reaction, in the case of the mixture of two solutions saturated with a neutral salt, the nitrate is positive with reference to a sulphate, the sulphate with reference to a phosphate, &c.

8. When several acid solutions, neutral or alkaline, are placed alongside of one another, so as to mix slowly, the electric effects produced are the resultant of the individual effects which take place at each surface of contact.

9. Contrary to the opinion of Volta, we may make an electric chain, or rather a closed circuit solely with liquids, in which an electric current will circulate, and by which phenomena of decomposition and recomposition may be obtained, if there are in the circuit bodies which are conductors of electricity. Living organised bodies present numerous examples of a circuit of this kind, giving place to electro-chemical effects, which have not yet been studied.

While occupied with the study of the principle governing the disengagement of electricity in chemical action, M. Becquerel has endeavored to bring the principle to a practical use. A long time since he applied it to the treatment of ores, and he has succeeded in extracting lead and silver from their respective ores without the intervention of heat, beyond what is necessary in a simple

roasting. An experiment has been made on more than 30,000 kilograms of ores from Mexico and different parts of the globe. The great solvent which he uses is common salt. We will give further details in our next communication.

Pyro-electric currents.—In the course of the preceding experiments, M. Becquerel observed that glass in fusion was a conductor of electricity. This conductibility begins to be sensible at 300° C. He has not been slow in finding a means of applying the heat lost in furnaces to the production of electricity. In view of this conductibility of glass in fusion, he substitutes it for acids and aqueous saline solutions in a battery. He obtains thus an element of a battery which remains constant, and which is sufficiently energetic to decompose water. Compared with a Bunsen's couple of the same size, it has about one-fourth the intensity.

These batteries, which in distinction from the hydro-electric and thermo-electric, M. Becquerel calls pyro-electric batteries, may be arranged in different ways. The following are two:

1. In a crucible placed in a furnace, pulverised glass is introduced, with 0·25 of carbonate of soda to hasten fusion; then a long bar of iron and another of copper are inserted in it, being fixed in a vertical position, and separated from one another. It is perceived that in this battery the soluble metal is the iron which is in fact oxydized; but this oxyd becomes dissolved in the mass in fusion, and the metal is constantly kept bright.

2. The barrel of a pistol is taken, and in it a tube of green glass is inserted enclosing a cylinder of copper; after having filled all the interstices of the barrel and of the tube with powdered glass, the whole is placed horizontally in a furnace, and the barrel and the copper cylinder are put in communication with apparatus for collecting the electricity.

These currents are not thermo-electric; for if the glass is removed, a galvanometer put in communication with the iron and copper rests at zero.

M. Becquerel considers it probable, in view of these pyro-electric currents, that terrestrial electric currents exist in contact with or near the junction of the solid part of the globe with the part in fusion, where there may be solid conducting substances partially empasted in the melted silicates in the manner of a pyro-electric couple.

On the electricity produced during the evaporation of salt-water.—For a long time it was admitted, on the researches of M. Pouillet, that the electricity produced during the evaporation of water containing a saline substance in solution, was due to the chemical segregation of the two substances, water and salt. Some years since, M. Riess and M. Reich showed that this electricity proceeded from the friction of the water against the sides

of the vase. This fact is proved anew by the researches just published of M. Gaugain, although the results obtained differ in the details from those of the German physicists.

Economical illumination by Electric light.—The last winter, the General Dock Company, hurried in the founding of its establishment, was obliged to work night and day. It undertook to remove in a short time the whole of a considerable hill: 1600 workmen, 800 at a time, were kept at work without interruption. In order to illuminate the works during the hours of the night, they proposed to use electric light. This mode of illumination has been often used in Paris in works at night; but in this case it was continued for 4 months, and proved to be an economical method of lighting. Fifty of Bunsen's elements were at once in action, and when the light after a while diminished, another 50 were substituted. Two electric lanterns served to light the space where the 800 workmen were employed. The expense per lantern was as follows:

Superintendent, per day, ...	4·50 francs.
Mercury, ...	5·00
Zinc, ...	4·50
Points of charcoal, ...	1·40
Nitric acid, ...	1·80
Sulphuric acid, ...	1·84
Total, ...	19·04

The cost, hence, of lighting the 800 workmen, was 38 francs 8 centimes per night, or 4½ centimes per man. This is a very considerable economy, and the work went on with a regularity which would have been impossible with any other mode of illumination; and besides it was accomplished without any danger, although the place was incessantly traversed by locomotives engaged in transporting the earth.

Decomposition of Kyanite by galvanic heat.—Another use has been made of electricity, and this of a chemical nature. On attaching to one of the charcoal points of a Bunsen's battery of 80 elements a small lamellar fragment of kyanite, which, as is well known, is very infusible, M. Duvivier has succeeded in fusing it in 3 or 4 minutes; the elements of which it consists were in part dispersed, and the aluminium, freed from oxygen, appeared at the surface of the substance in fusion. A small globule became fixed to the surface of the assay, which was flattened on cooling; and other globules remained imbedded in the melted mass. The author has extracted some of the supposed aluminium, but has not examined its physical properties, and we cannot say that it was pure; it may have contained silicium, proceeding from the silica. Has this deoxydation been produced by the heat

alone? Some physicists may think so. For ourselves, we believe that the reduction is due to the volatilised carbon; for it is well known that the luminous arc is never produced without a transfer of material, and the material transferred in this case is nothing else but incandescent carbon.

Electro-magnetic Machine.—On the Report of M. Becquerel, the Academy of Sciences has decreed to M. Marié-Davy, Professor in the Faculty of Sciences of Montpelier, a reward of 2000 francs for an electro-magnetic machine of his invention. In this machine, the electro-magnets act *by contact*. There is a cylindrical armature in communication with the axis which by its action it puts in motion, and which revolves in a circle carrying at intervals horse-shoe magnets. An analogous machine has been described and since patented in England by Mr. Talbot. We are ignorant of the force of Talbot's machine; that of Marié is very feeble, and we doubt if electricity will ever replace steam so long as the battery is not more economical. To increase the force of his motor wheel, the Academy has engaged M. Marié to replace the cylindrical armature by circular electro-magnets acting by opposite poles on the horse-shoe magnets. By this means, he will increase much the force without adding to the expense. M. Marié is now occupied with this improvement.

Magnetism by Rotation.—A German Journal relates the following experiment without mentioning the author. A watch-spring, not magnetic, suspended at centre by means of a fibre of silk, remains in equilibrium in any position, regardless of the earth's magnetism. But if a pistol containing a lead ball is fired directly beneath the spring, parallel to it, the spring becomes magnetic and takes the position of a magnetic needle. The author of the journal attributes this magnetism to the shock or undulation of the air produced by the passage of the ball.

We may give a simpler explanation, if we suppose the ball, which has a rotary movement in its passage, to become magnetic under this influence, as we have claimed in our remarks on the origin of the earth's magnetism.* Once magnetised, it induces magnetism in the steel spring, acting thus like an ordinary magnet. By interposing a screen between the spring and the line of the ball, it will still be magnetised if our explanation is correct, and also if the ball is fired above in a contrary direction the polarity should be the same, provided the ball has the same rotation in each case. Although this is only conjecture for the future to verify, I will take this opportunity to correct an opinion too formally expressed in the note on page 117 of this Journal, vol. xvii, written when discouraged after being disappointed in several trials; I hope soon to establish the contrary and without having recourse to the experiment alluded to above.

* This Journal, January, 1854, xvii, 116.

Experiments with reference to firing mines by electricity.—This subject which has received much attention, is to become of practical value through the efforts of Colonel Verdiè and Captain Savare of the Engineer Corps, who propose to substitute in place of Bunsen's battery for firing the powder, the machine of Ruhmkorff,† or that of Clarke. An interesting report on the subject made to the Academy by Marshal Vaillant, Minister of War and member of the Institute, announces the result as accomplished. But as the process for the purposes of war must be rendered familiar by practice to be of value, M. Vaillant does not consider that the time for using the process has yet come. He has ordered renewed trials, and to contribute toward it on his side, he has given the necessary orders that each School of Engineers shall have a Ruhmkorff's apparatus at its disposal. The processes employed by M. Verdiè and M. Savare differ somewhat, each in points of importance, but there is no space to describe them here.

Various Memoirs.—For want of space, we can only allude to the following papers:—An *Electric thermometer*, fitted for a boiler or an apartment kept at a constant temperature, by M. Maistre.—*Researches on the influence of Chloroform on the Sensitive Plant*, by M. Leclerc, showing that it is impressed by it perhaps like animals.—*Treatise on the relation which exists between the electro-motive force of the muscular current and that of different sources of dynamical electricity*, by Jules Regnauld.

In the science of Optics there have been several papers, among which we mention, *The determination of the emissive powers of bodies for light*, by MM. de la Provostaye and Desains; these experimenters have operated with incandescent bodies; platinum is more emissive than gold; and the emissive power of gold is 10 times more feeble than that of oxyd of copper.

Chemistry has as usual been richly represented. In the first place, M. Biot announces to the Academy the publication of the posthumous work of Laurent, entitled "Méthode de Chimie," and read on the occasion, the note with which he accompanies the work, and in which, under the form of *advice to the reader*, he points out the special end which Laurent proposed in his great work. A translation of this note is published in the latter part of this volume.—M. Rivot, superintendent of the Laboratory at the School of Mines, has brought forward *new methods of treating ores of copper*.—M. Frémy has communicated the results of his *researches on the ores of Platinum*.—The same chemist has presented two extended memoirs *on the composition of the eggs of different animals*, an investigation carried on in connection with M. Valenciennes, the zoologist.—M. Dessaignes is studying the *products of the transformation of creatine*.—M. C. Montrand has experimented *on the more economical manufacture of*

† This Journal, Jan., 1853.

phosphorus by treating phosphate of lime with carbon and chlorhydric acid.—Finally, the investigators of aluminium are giving themselves much labor, but still do not succeed in preparing this metal except at great expense.

Dilatation and Contraction of Metallic Plates.—The instruments for measuring dilatations of metallic plates are of great delicacy, giving results with very close precision. There are cases, however, in which a hundredth of a millimeter in difference of length may be of value, and this is the fact with the standard meter, the basis of the metric decimal system. M. Silbermann, Superintendent of the Conservatory of Arts and Trades, has just carried the precision to 3-thousandths of a millimeter. It is known that a rule suspended by one end becomes elongated thereby, and one standing on its end, owing to its weight, is shortened: and by placing the rule in a horizontal position again, it is supposed to take its original length. By employing his process, the germ of which is presented in a former work of this physicist,* M. Silbermann has shown that the rule that has been suspended retains its increased length when placed horizontally; and so with the rule that has stood on its end. The difference is only in thousandths of millimeters; still if it can be measured, this is sufficient reason why it should not be neglected.

New Greek Fire.—The war in the east has stimulated the zeal of those in Europe who are interested in improving the art of destruction. Projects the most remarkable and curious are proposed. Being persuaded that one of the means of preserving peace to humanity consists in perfecting our methods of destroying life, and not desiring that in this respect one nation should be more favored than others, we mention here some of the projects which rest on serious principles.

The Greek fire has at different times engaged attention without its being exactly known in what it consists. In 1755 a goldsmith of Paris, named Dupré, discovered an inflammable liquid which burned under water. Louis XV. allowed him to make experiments in the canal of Versailles, and then in different seaports, to try the power of the liquid in setting vessels on fire. It is said that the results produced were terrific. However the king believed it his duty to refuse the advantages which the invention promised. He withheld Dupré from publishing his discovery, and gave him a pension. Dupré died and carried off his secret.

In the month of April last, the photographer, Niepce de St. Victor, while studying benzine as an ingredient of a varnish, observed that this carburet,—which is very inflammable in the open air and at a low temperature by the simple contact of a small flame, while being insoluble in water and having a density

* This Journal, January and March, 1853.

of 0·85,—has eminently the property of burning on water. He then remarked that on throwing on water some benzine containing a fragment of potassium or of phosphuret of calcium, either of these substances set fire promptly to the benzine, by becoming inflamed through contact with the water.

In two experiments made each time with 300 grammes of benzine and half a gramme of potassium contained in glass vessels, the breaking of these vessels as they floated on the water, caused the benzine to spread over a large surface; the potassium taking fire produced an immense flame, which was very hot, and continued for about one minute, notwithstanding a strong wind in one case and a smart shower of rain in the second.

The first experiment was made on the 30th of April, on the Seine, and the second on May 2nd, in the basin of the Jardin du Palais Royal.

By request of the Minister of War, M. Niepce undertook to examine into the liquids susceptible of burning when used in the interior of hollow projectiles. In concert with M. Fontaine, a manufacturer of chemical products, he set himself to the work, and obtained the results here given. A mixture consisting of 3 parts of benzine and 1 of sulphuret of carbon, being put into a hand-grenade, previously heated to a temperature below that of boiling water, produced a disengagement of vapor which took fire on contact with a small flame; and a fine jet of flame was obtained much less smoky than that of pure benzine, and which continued to burn until the whole was consumed. For heating the hollow projectile, either a moment's immersion in boiling water, or contact with burning coals may be employed.

The mixture of benzine and sulphuret of carbon, of the proportions mentioned, floats on water, and its flame has remarkable burning qualities, when the sulphuret contains some phosphorus in solution; and it is proposed to use it in setting fire to wood. Oil of naphtha and oil of petroleum highly rectified are nearly as inflammable as benzine, and burn on water as readily. But their flames are not so hot. The oil of petroleum, benzine and sulphuret of carbon, as they are not expensive, it is proposed to use in war, either for burning an enemy's vessel, or for defending a place. We have read in the Journal "Cosmos," a programme prepared by a General of Engineers for defending a besieged town, and doing the greatest amount of mischief to the assailants.

Coupled Cannons.—This is another weapon of war, the effects of which may be terrible. It is brought forward by M. Ador. Two cannon have the same breech, and diverge at a given angle; they have a common charge of powder, a single touch-hole and a single cap. In each of these cannon, which are accurately bored and polished, a piston of a cylindrical form is fitted, having the same calibre as the cannon, carefully turned, polished

and greased. These two pistons are united together by an iron cord or wire when used with a musket, or by an iron chain from a meter to a hundred meters in length when with cannon. The pistons serve as projectiles; when fired, they straiten the chain between them, and flying through the air, they sweep every thing before them.

Photography—Heliographic engraving.—The following process invented by M. Baldus, appears to bring to perfection the method of engraving by the aid of the sun. The results obtained are very beautiful; and although the author has not described to us fully all the details, we know enough to give a general idea of his method.

On a plate of copper covered with petroleum a photographic proof on paper of the object to be engraved is placed; this proof is a positive, and will necessarily make a negative on the metal by the action of the light. After an exposure of a quarter of an hour to the sun, the image is reproduced on the resinous coating, but it is not yet visible; it is made to appear by washing the plate with a solvent which removes the parts not impressed by the light, and brings out a negative picture made by the resinous tracings of the bitumen. The designs are very delicate; the tracings receive solidity by an exposure during two days to the action of a diffuse light. When thus hardened, the plate of metal is plunged into a bath of sulphate of copper and is then connected with the pole of a battery; if with the negative pole, a layer of copper in relief is deposited on the parts of the metal not protected by the resinous coating; if with the positive pole, the metal is graved out in the same parts, and thus an etched engraving is obtained.

So that at will a raised or etched engraving may be made, the former to be printed like a wood-cut, the latter like ordinary copper plate engraving.

Collodion.—At one of the recent sessions of the Academy of Sciences, MM. Bisson brothers exhibited a photograph of the principal front of the Louvre; it was a positive on paper, 140 centimeters in length and 60 high, produced from a negative on collodionised glass. It consisted of 3 separate photographs, as similar in tone of coloring as if taken at a single operation. The operation was made with "collodion anticipé," the plates having been prepared in the workshop, and carried to the place after having been rendered sensitive; the authors affirm that these plates preserve their sensitiveness for several hours.

Société d'Encouragement pour l'Industrie Nationale.—We briefly allude to the recent annual session of this Society, held as usual for the distribution of medals to inventors who have become distinguished during the year by their inventions, and also to foremen who have been noted for their morality, intelligence,

and spirit of invention. Twenty-five among these latter have received bronze medals as well as books. All were distinguished for having made some improvements in the processes of their manufactures. Medals of bronze, of gold, or of platinum have been awarded to inventors, whose inventions have been successfully carried out. Some among these are already known to our readers; they are,—M. Dubrunfaut, for his economical production of alcohol from the juice of the beet;* MM. Girard and Aubert, for the impulse they have given to the caoutchouc industry;† M. Mirand,‡ for the successful application of the Electrical Telegraph to the wants or convenience of private life. We propose to describe another time his apparatus, which is already in use in several large houses.

We should also mention a dynamometer of excellent construction, for measuring the resistance to rupture of a band of tissues, an instrument which the public authorities, the manufacturers of tissues, and the marine propose to adopt, as it is admirably adapted for trying the strength of tissues, cordage, &c. The author of this dynamometer, M. Perreaux, received a platinum medal.

The session of the Academy was closed by a very fine address by the President, M. Dumas, on the past and future of Electricity. The poetic imagination of the orator more than once carried him too far. From reading the discourse one would seriously believe in the diamonds prepared by M. Despretz by means of the galvanic battery. The electro-magnetic machine of Marié-Davy was represented as completed, and as realizing the force of a one-horse steam engine, at an expense of 2 francs per day: the public has believed it, and there will be a grievous disappointment for M. Marié-Davy on the day when the machine he has proposed to construct, is put in action.

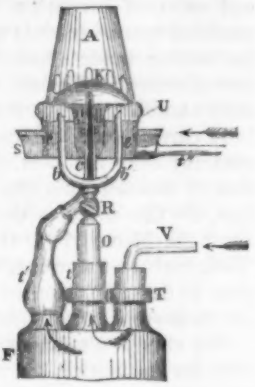
Economical Lamp for obtaining high temperatures.—M. H. St. Claire Deville, Professor of the Normal School, in order to carry on analysis by the dry way and the reduction of ores at this school, has been led to contrive an economical lamp capable of affording all the heat required. He burns a hydro-carburet purchased at little cost in the shops. Camphene would answer equally well.

In the lamp, the burning fluid used is brought to the state of vapor and inflamed before a blowpipe with a large aperture, the air of which is furnished by the bellows of an enameller's lamp. But a few seconds are required to raise a platinum crucible to the temperature of melting iron.

In the annexed figure, F is a reservoir furnished above with 3 tubulures, T, t, t'. By means of the bellows the air is injected into F through the tube V, which is inserted in T; t carries the

* This Journal, Sept. No., p. 274. † Ibid, p. 277. ‡ Ibid, Jan., 1853.

vertical tube O, which has a stopcock at R, and above divides into the two arms b, b', which pass into a metallic box U, and terminate in its upper part in open extremities cut off obliquely. The box U contains the burning fluid e, partly filling it; it connects with a reservoir by t'', which is kept at a constant level. The centre of this box is a cylindrical tube, closed below, through which passes the blowpipe e, a continuation of the tube t', the left tubulure (in the figure) of the flask F. The tube which is at the middle of the box U, and envelops the blowpipe c, has several small holes u, u, communicating with the empty (or upper) part of the box U.



Above the blowpipe, and resting in a furrow in the top of the box U, there is a copper cup K, pierced at the centre with a hole for the passage of the jet of vapor which escapes from the holes u, u, u, after the bellows are put in action.

To prevent the burning fluid from becoming too much heated, there is a trough S, containing water. Before lighting the lamp, the fluid in L is heated till the water in the trough boils; then the bellows are made to act, and the jet of vapor is lighted; after which the heat disengaged by the lamp is sufficient to continue the vaporisation of the fluid.

Above the box L, there is a chimney A, having a series of holes around, near its bottom, for drawing in air on the flame of the apparatus.

M. Deville observes that those hydro-carburets which give the densest vapors, and also have the lowest boiling point, afford the most heat.

ART. XLI.—*Observations on the Nomenclature of the metals contained in Columbite and Tantalite;* by Prof. A. CONNELL.*

IN 1801 Mr. Hatchett announced the discovery of a new metallic substance, contained as an oxygen acid combined with oxyd of iron in an undescribed heavy black mineral from Connecticut. To this new metal Mr. Hatchett gave the name of *columbium*, and the ore in which he found it has usually in this country been called *columbite*. A year afterwards Ekeberg announced a new metal which he called *tantalum*, in two Swedish minerals, which he distinguished by the names of tantalite and yttrotantalite.

* Phil. Mag., June, 1854, p. 461.

A few years afterwards, Dr. Wollaston conceived that he had succeeded in establishing that columbium and tantalum are identical; and this view was tacitly acquiesced in by the greater portion of the chemical public for many years, the metal and its ores usually obtaining in this country the names of columbium and columbite, and on the Continent the names of tantalum, and tantalite and yttrotantalite. A mineral was also discovered at Bodenmais, which was held to contain this same metal.

This state of things continued till about 1846, when M. H. Rose of Berlin published a series of researches on the ores from these different localities, from which, so far as I can understand the matter, he drew the following conclusions: first, that the metal in the Swedish tantalite is a distinct metal, with its peculiar oxygen acid and other combinations, and for this metal, the name of tantalum may be with great propriety reserved, being the metal discovered by Ekeberg, and by him called *tantalum*; secondly, that in the Bodenmais and American minerals two metals are contained, which M. Rose proposed to distinguish by the names of Niobium and Pelopium, the latter being supposed to be nearly allied to tantalum, but the former quite distinct in its characters.*

This view of Rose has more or less prevailed for the last eight years; although I confess it had always occurred to me, and occasionally I have spoken out the view, that Mr. Hatchett's memory had been rather hardly dealt with, since M. Rose had left him entirely out of view, although truly the first discoverer of the first known of these metals and minerals.

When cerium was ascertained not to be a pure metal, but to contain lanthanum and didymium mixed with it, no one thought of dropping entirely the name of cerium. It still belongs to an acknowledged metal, and the rights of its discoverers are unimpaired.

Precisely the same observation applies in regard to yttria and the new oxyds of erbium and terbium.

Other examples of the same kind might be quoted.

Now, on the authority of such precedents, when it was thought to be ascertained that the American columbite and the analogous Bodenmais mineral did not contain *one* new metal only, but at least two, justice seems to have required that the name of columbium should have been reserved for the more abundant of these two, just as the names of cerium and of yttrium have been preserved.

But how much more strongly does such a view hold good *now*, when it has been announced by M. Rose that the American and Bodenmais mineral contain only *one metal*, and for this metal he actually proposes the name of niobium?† Does it not follow very

* See Chemical Gazette, vol. iv, p. 349.

† Ibid, vol. xii, p. 149.

clearly that this metal ought to have the name of *columbium?* M. Rose has now come to the same conclusion at which Mr. Hatchett arrived fifty years ago, when he announced that one new metal, to which he gave the name of columbium, existed in the American mineral columbite. If the countrymen of the latter most distinguished analytical chemist have any sense of justice or regard for the memory of an eminent man—one with whom I am proud to say I had a slight acquantanee, and from whom I received some kindness—they will now unite for the future in support of his just right not to be forgotten and entirely laid aside in this matter. There cannot be a better opportunity than the present for taking this step.

I am very far from wishing to overlook the important researches of M. Rose on this, as on so very many other interesting topics, and we shall always feel grateful for his further investigations regarding columbium and its various oxyds and other combinations. But we ought not to overlook what was done before him.

The matter is now reduced to a very simple issue.

We have *columbium* in the American and Bodenmais columbites, and probably now in some other minerals.

We have *tantalum* in Swedish tantalite and yttrotantalite, and probably in some other minerals.

Of all courses, one of the most ill-advised seems that followed by some English chemists, of giving occasionally the name of columbium to tantalum, which, as I understand the matter, is now quite ascertained to be different from any of the other metals. This course can only lead to confusion. Tantalum is not columbium.

Art. XLII.—*Murchison's Siluria.**

[This recent work by Sir R. I. Murchison is an able and instructive summary of the history of the earliest rocks that contain organic remains.

In 1839 Sir R. I. Murchison published his Silurian System in two parts, in a quarto of 768 pages copiously illustrated. This was followed in 1845 by another great work of 652 pages quarto, embellished with the most ample and beautiful views, sections, maps, &c., illustrating the geology of Russia in Europe and the Urals. As a companion, a second volume of 512 pages appeared at the same time, devoted to the Paleontology of the

* Siluria: The History of the oldest known Rocks containing Organic Remains with a brief sketch of the distribution of Gold over the earth. By Sir Roderick Impey Murchison, F.R.S., F.L.S., etc. etc. 523 pp. large 8vo, with 37 plates and many wood-cuts. *London*, 1854.

regions explored, illustrated by 50 quarto plates. These volumes on Russia and the Urals are the joint production of Sir R. I. Murchison, Mr. Edouard de Verneuil of France and Count Alexander von Keyserling of Russia.

The recent work of Sir R. I. Murchison is an able resumé of all that has been done by these writers, together with the results of other laborers in the science, among whom are Professor Sedgwick of Cambridge, England, the geologists of the Ordnance Survey in Great Britain, and many eminent men on the continent of Europe and in America. The observations on gold and its distribution, with which the volume closes, are of much practical value, although only incidentally connected with the main object of the work.

The important labors of the author of Siluria have been carried through with signal ability, and at a great outlay of time and money. Geology is largely indebted also to Prof. Sedgwick for his researches among the oldest fossiliferous rocks. But Murchison appears to have first made out the correct relations of these early strata. To him we owe the judicious exposition of the whole subject in the elaborate works which he has put forth. The candor and liberality manifested by the author are worthy of the works which they adorn. His investigations have extended above the coal, into the New Red Sandstone, the Permian beds, and the Triassic, and the present work embraces these limits. The full exhibition of these great zones of primeval life, from its earliest dawn through many successive ages, to the era of the first reptiles, is most interesting and instructive. A general review of the subject, partly historical and partly expository, is presented in the introductory chapter of the Siluria which we here cite. We take pleasure in thus showing our appreciation of the extended labors of the author.—B. S.]

The earliest condition of the earth is necessarily the darkest period of its geological history. The favorite hypothesis concerning the origin of the planet, founded on astronomical and physical analogies, is, that it assumed the form of a flattened spheroid from rotation on its axis when in a fluid state. Reasoning upon this idea, and looking to the structure of those rocks which either lie at great depths or have been extruded from beneath, the geologist has inferred that the crystalline masses, including granites which issued out from below all other rocks, and constitute possibly their existing substratum, were at one time in a molten state. The theory of a central heat, at first sufficiently intense to maintain the whole terrestrial mass in a state of fusion, but subsequently so far dissipated by radiation into space, as to allow the superficial portion to become solid, has been adopted by the greater number of philosophers who have grappled

with the difficult problem of the first conditions of our planet. Most of them likewise have believed that all the great outbursts of igneous matter, by which the crust has been penetrated and its surface diversified, were merely outward signs of the continued internal activity of that primordial heat, now much repressed by the accumulations of ages, and of which our present volcanoes are feeble indications. If, then, the mathematician has correctly explained the causes of the shape of the globe, the geologist confirms his views when, examining into the nature of its oldest massive crystalline rocks, he sees in them clear proofs of the effects of intense heat. This original crust of the earth was subsequently, we may believe, broken up by protruded masses, which issuing in a melted condition, constituted the axes and centres of mountain chains. Each great igneous eruption gave out substances that became, on cooling, solid rocks, which, when raised into the atmosphere, constituted lands that were exposed to innumerable wasting agencies; and thus afforded materials to be spread out as deposits upon the shores and bed of the ocean. In these hypothetical views concerning the production of the earliest sediments formed under water, we seem to reach a primary source; and once admitting that large superficial areas were originally occupied by igneous rocks, we have in them a basis from which the first sedimentary materials were obtained.

The earlier eruptions having necessarily occasioned elevations at some points and collapses or depressions at others, such changes of outline, aided by the grinding action of water, would occasion the formation of bands of sediment, which, adapting themselves to the inequalities of the surface, must have been of unequal dimensions in different parts of their range. In this way, we may imagine how, by a repetition of the processes of elevation and denudation, the earliest exterior rugosities of the earth would be in some places increased, while in others they would be placed beyond the influence of sedimentary accumulation. May we not also infer, that the numerous molten rocks of great dimensions which were suddenly evolved from the interior at subsequent periods, must have made enormous additions to the solid crust of the earth, and have constituted grand sources for the augmentation of new strata?

Turning from the igneous rocks to crystalline stratified deposits, we now know that a great portion of the micaceous schists, chloritic and quartzose rocks, clay-slates, and limestones, once called primary, were of later origin. Many of these are nothing more than subaqueous sediments of various epochs, which have been altered and crystallized at periods long subsequent to their accumulation. This inference has been deduced from positive observation. Rocks, for example, have been tracked from the districts where they are crystalline, to spots where the mechan-

ical and subaqueous origin of the beds is obvious, and from the latter to localities where the same strata are wholly unchanged, and contain organic remains. Transitions are thus seen from compact quartz rock, in which the grains of silica are scarcely discoverable with a powerful lens, to strata in which the sandy, gritty, and pebbly particles bespeak clearly that the whole range was originally accumulated under water. Other passages occur from crystalline, chloritic, and micaceous schists, to those clay-slates which are little more than consolidated mud, and from crystalline marble to common earthy limestone, in which organic remains abound. These and similar metamorphoses embrace the consideration of changes, like those, for example, by which ordinary limestone has been converted into dolomite and sulphate of lime or gypsum, or shale into mica-schist, as is seen in the secondary and tertiary rocks of the Alps.*

Elementary works will have, indeed, informed the student, that such changes of the original sediment have been generally accounted for by the influence of great heat proceeding from the interior of the earth, and which at different former periods manifested its power in the eruption of granites, syenites, porphyries, greenstones, and other substances formed by fusion. Let it, however, be understood, that the prodigious extent to which the metamorphism of the original strata has been carried in mountain-chains, and at different periods through all formations, though often probably connected with such igneous outbursts, must have resulted from a far mightier agency than that which was productive of the mere eruptions of molten matter or igneous rocks. The latter are, in fact, but partial excrescences in the vast spread of the stratified crystalline rocks,—symptoms only of the grand changes which resulted from deep-seated causes; probably from the combination of heat, steam, and electricity, acting together with an intensity very powerful in former periods.

Processes now going on in nature on a small scale, or imitated artificially by man, may enable us to comprehend imperfectly in what manner some of these infinitely grander ancient metamorphoses were effected; and the experimental science of chemistry when more extensively applied to the analysis of rocks, will, it is hoped, some day reveal still more important truths in this, which is still one of the most obscure points in the range of geological phenomena.

But speculations on such physical operations as those which have affected the surface of the earth, are not here called for. At all events, the earliest of the phenomena, with which alone we are at present concerned, or the first formation of the known crust of the planet, belongs to a period in which no definite order,

* See Alps, Appenines, &c., Quarterly Journal Geol. Soc. Lond., vol. v, p. 157, *et seq.*

—still less any trace of life,—has been deciphered by human labor.*

The design of this work is much more attainable. Its aim is to mark the most ancient strata in which the proofs of sedimentary or aqueous action are still visble,—to note the geological position of those beds which in various countries offer the first ascertained signs of life, and to develop the succession of deposits, where not obscured by metamorphism, that belong to such protozoic zones. In thus adhering only to subjects capable of being investigated, it will be seen, that geology, modern as she is among the sciences, has revealed to us, that during cycles long anterior to the creation of the human race, and while the surface of the globe was passing from one condition to another, whole races of animals—each group adapted to the physical conditions in which they lived—were successively created and exterminated. It is to the first stages only of this grand and long series of former accumulations, and to the creatures entombed in them, that attention is now directed.

The convictions at which I have arrived being the result of many years of research, I have been urged by numerous friends to give a condensed, and, as far as is practicable, a popular view of the oldest sedimentary rocks and of their chief organic remains, and thus to throw into one moderate-sized volume the essence of my large works,† as sustained by the publications of many other authors.

Geologists are now pretty generally agreed, that the oldest organic remains which are traceable, pertain to the lower division of the rocks termed Silurian; but before any description of these ancient deposits, or of those preceding them, is given, a few words are required, in explanation of the researches by which our acquaintance with the earliest vestiges of life and order in the protozoic world has been attained.

One of the chief steps which led to the present classification, as admitted by my contemporaries, was the establishment of the "Silurian System" of rocks and their imbedded fossils. Before the labors which terminated in the publication of the work so named, no one had unravelled the detailed sequence and characteristic fossils of any strata of a higher antiquity than the Old Red Sandstone; and even that formation was only known to be the natural base of the Carboniferous or Mountain limestone, and to contain a few undescribed fossil fishes. Not only were the re-

* The reader who desires to study the laws by which the superficial temperature of the earth has been regulated in the immensely long subsequent geological periods, will find them well explained in the profound essay of Mr. W. Hopkins, "On the causes of changes of *climate* at different geological periods," Quart. Journ. Geol. Soc. Lond., vol. viii, p. 56.

† See Silurian System, Murchison, 1839; and Russia in Europe and the Ural Mountains, by Murchison, de Verneuil, and de Keyserling (J. Murray, 1845).

lations and contents of all the inferior strata undefined, but even many rocks which are now known to be younger than the Silurian, were then considered to be of much more remote antiquity. No one had then surmised, that the great series of hard slates with limestones and fossils, which have since been termed Devonian, is an equivalent of the Old Red Sandstone, and younger than, as well as distinct from, the deposits of the still older Silurian era. On the contrary, British authorities believed (and I was myself so taught) that the schistose and subcrystalline rocks of Devonshire and Cornwall were about the most ancient of the vast undigested heaps of greywacke. In short, the best geologists* of my early days were accustomed to leave off with such rocks, as constituting obscure heaps of sediment, in and below which no succession of "strata as identified by their fossils" could be detected. The result of research, however, has been the elimination of several well-defined groups, all of which were formerly merged in the unmeaning German term "grauwacke." (See Chapter 14.)

Desirous of throwing light on this dark subject, I consulted my valued friend and instructor, Dr. Buckland, as to the region most likely to afford evidences of order, and by his advice I first explored, in 1831, the banks of the Wye between Hay and Builth. Discovering a considerable tract in Hereford, Radnor and Shropshire, wherein large masses of grey-colored strata rise out from beneath the Old Red Sandstone, and contain fossils differing from any which were known in the superior deposits, I began to classify these rocks. After four years of consecutive labor, I assigned to them (1835) the name Silurian, deriving it from the portion of England and Wales, in which the successive formations are clearly displayed, and wherein an ancient British people, the Silures, under their king Caradoc (Caractacus), had opposed a long and valorous resistance to the Romans. Having first, in the year 1833, separated these deposits† into four formations, and shown that each is characterized by peculiar organic remains, I next divided them (1834, 1835) into a lower and upper group, both of which I hoped would be found applicable to wide regions of the earth. After eight years of labor in the field and closet, the proofs of the truth of those views were more fully published in the work entitled the "Silurian System" (1839).

* See those classical works, the first Geological Map of Mr. Greenough, and the Geology of England and Wales, by the Rev. W. D. Conybeare.

† For the first tabular view of these four formations, the bottom one resting on the unfossiliferous greywacke of the Longmynd, see Proceedings Geol. Soc. Lond., vol. ii, p. 11, Jan. 1834. The characteristic fossil species were even then enumerated, and hence the classification which is now sustained is essentially twenty years old. It had even been previously stated by me, that the lowest known fossil-bearing formation, or the "*black trilobite schists and flags of Llandeilo, probably exceeded in thickness any of the superior groups.*"—Proc. Geol. Soc., vol. i, p. 476, 1833.

During my early researches, it was shown that the lowest of these (1833) fossil-bearing strata reposed, in the west of Shropshire, on a very thick accumulation of still older sediment, as exposed in the ridge of the Stiper Stones, and the Longmynd mountain; and the strata of the latter not offering a vestige of former life, they were consequently termed unfossiliferous grey-wacke.

At that time it was also supposed, that the contiguous slaty region of North Wales, then under the examination of Professor Sedgwick, consisted of rocks, in part fossiliferous, and of an enormous thickness, which rose up, according to my friend and fellow-laborer, from beneath my Silurian types. Hence, another term, or that of Cambrian, was afterwards, or in the year 1836, applied to masses supposed to be inferior, before their true relations to the Silurian strata of Shropshire and Montgomeryshire had been ascertained. This assumed inferiority of position in the slaty rocks of North Wales being considered a fixed point, it was naturally thought, that such lower formations, the fossils of which were then undescribed, would be found to contain a set of organic remains, differing as a whole from those of my classified and published Silurian system. With other geologists, therefore, I waited for the production of the fossils which might typify such supposed older sediments; for in obtaining all the knowledge I had then acquired, by receding from upper strata whose contents were known to lower and previously unknown rocks, I had invariably found that the latter were characterized by many distinct and new organisms. This fact, which had been first established in the tertiary and secondary deposits, was thus proved to be universally applicable by the occurrence of similar distinctions in the Carboniferous, Old Red, and Silurian rocks.

It was, however, in vain that we looked to the production of a peculiar type of life from the "Cambrian" rocks. Silurian fossils were alone found in them; and the reason has since become manifest. The labors of many competent observers in the last fifteen years have proved that these rocks are not inferior in position, as they were supposed to be, to the lowest stratified rocks of my Silurian region of Shropshire and the adjacent parts of Montgomeryshire, *but are merely extensions of the same strata;* and hence the looked-for geological and zoological distinctions could never have been realized. In the following chapters it will be shown how Sir H. De la Beche, Professors Ramsay and E. Forbes, with Mr. Salter, and other geologists and palæontologists have demonstrated, that the fossil-bearing rocks of North Wales are both in their order and contents the absolute equivalents of the chief mass of the strata which had been described and named by me "Lower Silurian" in Shropshire and Montgomeryshire. These Government geologists have used my nomenclature in all

their works relating to North Wales, and have, in short, determined the question physically, as well as zoologically.*

But although in 1839, when my first work was completed, I held, in common with Professor Sedgwick, the erroneous idea of the infra-Silurian position of the rocks of North Wales, I soon saw reason to abandon that view, and to adopt (in the year 1841) the opinion which I have subsequently maintained. Thirteen years have elapsed since I was persuaded that the view I then took must be adhered to; first, because it had been ascertained that in Scandinavia, Russia, Bohemia, and other countries, the oldest traces of former life were the same as the lower Silurian types of the British Isles;—and next, because many of the fossils figured in my work as Lower Silurian had been detected in the slates of Snowdon, which were then considered to lie near the bottom of the so-called "Cambrian rocks."

The leading object, therefore, of the present work is, I repeat, to bring out the "Silurian System," not as a mere abridgment of its original form; but such as it finally became in the year 1849, when it was honored with the highest distinction which the Royal Society bestows,† and what it has proved to be, with the geographical and other additions made to it by the government surveyors at home, and by numerous geologists in other countries.

In extending my own researches to various distant lands, I found that as the true base of all rocks containing fossil remains was clear in Scandinavia, Russia, and Bohemia, and as the same fact was announced from North America, it was no longer difficult to describe the whole organic series *from a beginning*, and thus to record the succession of animals from their earliest known developments. In a word, as chroniclers of lost races, my associates and myself were enabled to register in our "Russia and the Ural Mountains," the types of former creatures from their apparent dawn. To the first chapters of that work, the reader is referred as fully explanatory of views which are here reiterated.‡

* See also Phillips, on the Malvern and Abberley Hills.—Memoirs, Geol. Surv., vol. ii, part 1, 1848.

† The Copley Medal.

‡ The reader who desires to consult the documents which explain how my induction was arrived at, is referred to a memoir entitled, "On the meaning attached to the term Silurian during the last ten years," which will indicate to him all my successive publications on this subject, including a geological map of England and Wales, published by the Society for the Diffusion of Useful Knowledge, in 1843. (Journal of Geol. Soc. Lond., vol. viii, p. 173. See also the memoir entitled, "On the meaning attached to the term 'Cambrian System,' and on the evidence since obtained of its being geologically synonymous with the previously established term 'Lower Silurian,'" Journ. Geol. Soc., Lond., vol. iii, p. 165.) At the same time that I must protest against the recent proposal to absorb my Lower Silurian into his Cambrian Rocks, let me record my high estimation of the original memoirs of Professor Sedgwick, especially those on North Wales, Cumberland, and the adjacent counties, which stand upon their own intrinsic merits. The publication on the palæozoic fossils of the Cambridge Museum, which he is bringing out in conjunction with

Then it was, that positive proofs, derived from a wide field of observation, enabled us to commence geological history, with an account of the entombment of the earliest animals recognizable in the crust of the globe; and also to indicate the successive conditions which prevailed upon the surface, in a long series of ages, and during the many changes of outline which preceded the present state of the planet. Then it was, that looking to the whole history of former life, as exhibited in the strata, it was demonstrated from phenomena in one great empire alone (as had to a great extent been shown in Britain), that during the formation of the sediments which compose the crust of the earth, the animal kingdom had been at least three times entirely renovated; the secondary and tertiary periods having each been as clearly characterized by a distinct fauna as the primeval series. In the work on Russia the sequence was thus followed out truly, from the most ancient fossil-bearing strata to the most recent stages in the geological series.

In this volume attention is chiefly restricted to what has proved to be the protozoic, or first era of life. The plan, therefore, pursued will be, so far, similar to that which was adopted in the earlier chapters of the work on Russia; and these first leaves of geological history will be written from the clear traces of a beginning,—a plan which, for want of knowledge, was impracticable in Britain when the "Silurian System" was published.

After a short sketch of the earliest and unfossiliferous sediments, full descriptions will be given of the Silurian rocks (Lower and Upper), followed by very brief accounts of the three overlying groups of palæozoic life, the Devonian, Carboniferous, and Permian.

The Devonian rocks were in previous years known only as the Old Red Sandstone, a name which has, indeed, become classical through the writings of Hugh Miller. These were termed Devonian, because the strata of that age in Devonshire, though very unlike the Old Red Sandstone of Scotland, Hereford, and the South Welsh counties, contain a much more copious and rich fossil fauna, and were demonstrated to occupy the same intermediate position between the previously described Silurian and Carboniferous rocks. At that time, however, none of the fossil fishes of the Scottish or English Old Red had been found in the sandstones, slates, schists, or limestones of Devonshire, or the

Professor M'Coy, will be, I doubt not, a lasting monument in the history of geological science. If that work had been published eighteen years ago, or in 1836, my friend, seeing that his Bala and my Llandeilo rocks were identical, might have proposed (although my fossils were first named and classified) that the Lower Silurian should be merged in the Cambrian. But, now that the terms Lower and Upper Silurian have been adopted in every country, the question is settled. My deep regret on the occasion of this difference of opinion has been expressed in the Preface; for in general views, as in private friendship, we are cordially united.

Rhine, and objections might have been raised to the opinion formed of the age of the deposits. But the discovery made in Russia,* and afterwards extended to Belgium and the Rhenish provinces, of Scottish ichthyolites being associated with numerous mollusca of the Devonshire rocks, firmly established the truth of the comparison.

The Carboniferous rocks, so elaborately and usefully developed in the British Isles, have been already well investigated by many writers, particularly by Professor Phillips, and have been found to extend, like the Silurian and Devonian, over immense regions in all quarters of the globe.

The great primeval or palæozoic series is now known to terminate upwards, in Europe, with certain deposits, for which, in the year 1841, I suggested the name of Permian. In the early days of geological science in England, this group was classed with the New Red Sandstone, of which it was supposed to form the base. But extended researches have shown from the character of its imbedded remains, that it is linked to the carboniferous deposit on which it rests, and is entirely distinct from the Trias, or New Red Sandstone, which, overlying it, forms the base of all the secondary rocks. The chief calcareous member of this Permian group was termed in England the Magnesian Limestone, in Germany the "Zechstein;" but as magnesian limestones are of all ages, and as the German "Zechstein" is but a part of a group, the other members of which are known as "Kupferschiefer" (copper slate), "Rothe todte liegende" (the Lower New Red of English geologists), &c., it was manifest that a single name for the whole was much needed. After showing how these variously named strata constituted one natural group, I therefore proposed to my fellow-laborers, de Verneuil and A. de Keyserling, that the vast Russian territory of Perm should furnish the required name. The term Permian† has, indeed, been adopted by several German authorities, and also by the Government Geological Surveyors of Britain.

In the opening chapter on the geology of Russia, we gave a general view of this palæozoic classification, as applied to Germany, France, Belgium, and North America; in all of which countries, as well as in Russia, it was shown, that a similar ascending order prevailed, from a base line of recognizable Silurian life, up through Devonian and Carboniferous deposits. In the nine years which have elapsed since the issue of that work, considerable additions have been made to our knowledge, and all of them sustain the truth of our generalization. We then scarcely knew of the existence of true Silurian deposits in Germany; nearly all the greywacke of the Rhenish provinces and the Hartz

* See Russia in Europe and the Ural Mountains, vol. i, p. 64.

† "Penéen" of D'Omalius d'Halloy. (See Chapter 12.)

having been assigned to the Devonian series. But since the opening out of the rich Silurian basin of Bohemia, which, in the hands of M. Barrande, has become the palæozoic centre of the continent, Thuringia and Saxony have been also found to contain Silurian rocks.

In Spain, several mountain chains have been shown by M. de Verneuil to consist of Silurian, followed by Devonian and Carboniferous rocks; whilst, in Portugal, Mr. Sharpe has described the first and last of these groups. Even Sardinia has exhibited, under the scrutiny of General A. della Marmora, her Silurian and superjacent coal deposits. Again, as Devonian and Carboniferous strata overlie older rocks in North Africa, and Devonian fossils occur towards Central Africa* and at the Cape of Good Hope, there are already fair grounds for believing, that a similar order pervades the axial lines or ancient mountains of that vast continent.

In northwestern Asia, the chief features of which are described by Humboldt and Rose, my colleagues and myself have explained how the Silurian rocks of the Ural chain are succeeded by younger palæozoic deposits, and Pierre de Tchihatcheff has indicated a great extension of similar formations over large tracts of Southern Siberia and the Altai mountains; whilst in northeastern Siberia, Adolf Erman has traced such rocks even to the Sea of Ochotsk.

In the giant Himalaya mountains, and in Hindostan, where till recently no systematic labors had been devoted to the older strata, we now know, that Silurian rocks, covered by secondary or mesozoic deposits, exist in those the highest mountains of the world; and that the Upper Punjaub contains a limestone charged with well-known carboniferous fossils, reposing, as in England, upon a red sandstone.† There is, indeed, every reason to believe that the mountain-chains of Tartary and China are composed, to a great extent, of these older rocks; for whilst extensive coal-fields have been long worked in the environs of the capital, Pekin, Devonian fossils of the very same species as those of England and the continent have recently been sent from Kwangsi, far to the south of Shangai. Other fossils, identified by de Koninck as Devonian forms, were brought by M. Itier, from the Yuennan province, one hundred leagues north of Canton.‡

* For North Africa, see Coquand, Bull. de la Soc. Géol. de France, 2nde Série, vol. iv, p. 1188. Some of the fossils collected by the enterprising traveller Overweg are also Devonian. For South Africa, the reader must consult a Memoir by Mr. Bain, not yet published in the Quart. Journ. Geol. Soc. Lond.

† The Himalayan data are described by Capt. R. Strachey; those of the Upper Punjaub, by Dr. A. Fleming. (Quart. Journ. Geol. Soc., vol. vii, p. 292, and vol. ix, p. 189.)

‡ See a description of the Chinese coal-field near Pekin, by Kovanko, Ann. des Mines de Russie, An. 1838, p. 191. No geologist can peruse Mr. Fortune's lively de-

In Australia, where a very short time since reference could be made only to rocks of the Carboniferous and Devonian age,* we hear of true Silurian strata containing fossils like those of the British Isles. Some species seem undistinguishable.†

In South America, the lofty Cordilleras and plateaux, whose mineral characters had been so admirably described by Humboldt, are shown by Alcide d'Orbigny to consist in great part of such ancient sediments. Still more clearly has North America been found to contain a vast succession of these palæozoic rocks, and especially of their lower members. Numerous geologists of the United States have demonstrated, that their ancient strata followed the same order on a very grand and usually unbroken scale (particularly in the western region); doubtless due to their having been exempted in such tracts from the intrusion of igneous rocks. Spread out in enormous sheets over the southern districts of Upper Canada, the Lower Silurian strata, invariably so called by every American geologist,‡ are there based on unfossiliferous slates, limestones and sandstones reposing on crystalline rocks, which, extending far northwards, are surmounted by other sedimentary masses similar to strata of the United States, and where Silurian fossils have been detected in limestones amid the polar ices. Adjacent to the southern end of this continent, similar remains have been collected by Darwin in the Falkland Islands.

In few of those regions, however, with the exception of North America (certainly not in the British Isles, where the strata are in many parts much obscured by igneous outbursts), is the sequence so undisturbed as in Scandinavia and European Russia. There, the successive primeval deposits extend over a large portion of the earth in regular sequence and in an unaltered state. Hence, though to the unskilled eye, Russia presents only a monotonous and undulating surface, chiefly occupied by accumulations of mud, sand, and erratic blocks, its framework, wherever it can be detected, exhibits a clear ascending series. The older sedimentary strata, deviating only slightly from horizontality, are there overlaid by widely-diffused masses of those Permian rocks which constitute the true termination of the long palæozoic period.

scription of the Bohea mountains, without suspecting, that a fine primeval succession may there be found. For the Chinese fossils, see Davidson, Quart. Journ. Geol. Soc. Lond., vol. ix, p. 353; and de Koninck, Bull. Acad. Roy. Soc. Belg., vol. xiii, pt. 2, p. 415.

* See Strzelecki's Australia, Foss. Fauna, Morris; M'Coy, Ann. Nat. Hist., 1847. [Also Dana's Rep. Geol. Expl. Exp., where many new species are described.—Eds.]

† Memoir by the Rev. W. B. Clarke, Quart. Journ. Geol. Soc. Lond., vol. viii; see also his collections, and those at the Government Museum.

‡ See particularly the works of James Hall and D. Dale Owen, the Reports of Logan—the chief geologist of Canada.

The following pages, as before said, will be chiefly devoted to the Silurian or first stages of this primeval series. They will be illustrated by wood-cuts representing the most important organic remains, and certain typical pictorial scenes, as well as vertical sections, chiefly taken from my original work. Faithful transfers from the original plates of the "Silurian System," will also be given, in a rearranged form, and with the modern nomenclature of the fossils.

If all the succeeding primeval rocks were to obtain the same amount of illustration as the Silurian, this work would be expanded far beyond the limits to which I must restrict it. The younger palæozoic, or the Devonian, Carboniferous, and Permian deposits, will therefore receive only such a description as may be sufficient to give the student a general view, and stimulate him to acquire a fuller acquaintance with them by consulting the various works wherein they are circumstantially described. But even the sketch of them in this volume will, it is hoped, suffice to show, that while the contiguous strata of two natural groups are intimately linked together by containing some species which are common to both, the principal fossils of each are certainly peculiar.

Although few mineral changes of the strata can be alluded to, an endeavor will be made to show, that gold, however it may now be spread over the surface, was originally accumulated in abundance in the older rocks only (especially in those which have been much altered), and in the associated eruptive masses.

Lastly, it is to be observed, that as the true sequence of the oldest fossiliferous strata was first detected in the British Isles, so the geological descriptions in this volume will be principally derived from our insular examples. At the same time, a general comparison will be instituted with the contemporaneous rocks of different quarters of the globe.

The importance of having, through patient surveys, mastered the obscurities which clouded the history of the earlier periods of animal life will thus, it is hoped, be rendered obvious, in showing that we have now obtained as correct an insight into the first fossil-bearing formations as we had previously acquired of the younger deposits.

ART. XLIII.—*On the Chemical Composition of Clintonite;* by GEO. J. BRUSH.

THE name Clintonite was given some twenty-five years since by Fitch, Mather and Horton to a micaceous reddish-brown mineral occurring at Amity in New York; previous to this, the mineral had been called Bronzite.

In 1832 Clemson* investigated its chemical composition and finding it to differ from Bronzite, gave to it the new name of Seybertite; later, in 1836, it was analysed by Richardson† in Thomson's Laboratory, and apparently unaware of its previous history Thomson considered it a new species and named it Holmsite.

The chemical composition according to Clemson and Richardson is:

	$\dot{S}i$	$\dot{A}l$		$\dot{F}e$	$\dot{M}g$	$\dot{C}a$	$\dot{M}n$	$\dot{Z}r$	$\dot{H}$	HF	
1,	17·0	37·6		5·0	24·3	10·7	—	—	3·6	—	*Clemson.*
2,	19·35	44·75	$\ddot{F}e$	4·80	9·05	11·45	1·35	2·05	4·55	0·90	*Richardson.*

The unaccountable discrepancy between these analyses led the writer to an examination of its composition.

The specimens analysed were of a reddish-brown or copper-red color and had a sp. gr. of 3·148. H.=5·5. Alone, B.B. infusible, loses its brown color and becomes opaque; heated in a tube gives off a small amount of water, which has a neutral reaction. It is entirely decomposed by concentrated hydrochloric acid, without gelatinizing. A qualitative examination showed the presence of silica, alumina, iron, zirconia, magnesia, lime, potash and soda; no reaction for manganese by Crum's test.

A special examination was made to determine the state of oxydation of the iron; for this purpose the mineral was decomposed by hydrochloric acid in an atmosphere of carbonic acid, the result proved the iron to be peroxyd. Considerable care also was taken in ascertaining whether zirconia was present, as over two pr. ct. were found by Richardson; the iron obtained in the analyses was therefore reëxamined and in every instance an undoubted reaction for zirconia was obtained. On careful examination of the specimens with a magnifier, a dark brown mineral resembling zircon was found to be intimately associated with the Clintonite. A qualitative examination gave all the reactions of zircon,—the writer is therefore inclined to believe that the zircon obtained in the analyses may be due to the associated zircon and not essential to the mineral.

* This Journal [1], xxiv, 171.

† Rec. Gen. Sci. May, 1836, p. 332, and Jour. f. Prakt. Chem., xiv, 38.

In the quantitative analyses, the decomposition was effected by fusion with carbonate of soda; the alkalies were determined by Smith's method with carbonate of lime; the separation of zirconia and iron was made by the presence of tartaric acid in an ammoniacal solution, and the iron was precipitated by sulphid of ammonium. A particular examination was made to prove the purity of all the precipitates obtained. The following are the results of two analyses:

	1.	Oxygen.		2.	Oxygen.	
Silica,	20·24	10·74*		20·13	10·69	
Alumina,	39·13	18·29		38·68	18·07	
Peroxyd of Iron,	3·27	0·98	19·47	3·48	1·04	19·29
Zirconia,	0·75	0·20		0·68	0·18	
Lime,	13·69	3·89		13·35	3·80	
Magnesia,	20·84	8·34	12·55	21·65	8·66	12·78
Soda,	1·14	0·29		1·14	0·29	
Potash,	0·29	0·03		0·29	0·03	
Water,	1·04	0·92		1·05	0·93	
	100·39			100·45		

Only one determination was made of the alkalies. A third incomplete analysis gave, Silica 19·73, oxyd of iron and zirconia 4·15, lime 13·43, magnesia 20·81, water 1·09.

A great difference between the above analyses and those of Clemson and Richardson is in the amount of water. To determine this point the powdered mineral was dried over sulphuric acid and then very powerfully heated by a blast-lamp; in four experiments but a trifle over 1 per ct. was lost.

The analyses do not give a satisfactory formula, the oxygen ratios are:

	$\ddot{S}i$	$\ddot{R}$	$\dot{R}$
No. 1,	10·74	19·47	12·55
No. 2,	10·69	19·29	12·78

The relation between $\ddot{R}$ and $\dot{R}$ is 3 : 2 or 6 : 4, and the most simple ratio is 3 : 6 : 4, but the silica is in excess and the real ratio is nearer $3\frac{1}{2}$: 6 : 4. If in Clemson's analysis the 5 pr. ct. of iron be considered to be peroxyd (5·0 $\dot{F}e$ = 4·5 $\ddot{F}e$), we have the ratios

$\ddot{S}i$	$\ddot{R}$	$\dot{R}$
9·02	18·92	13·76

which seems to render it probable that the true ratio for the mineral is 3 : 6 : 4, from which may be deduced the formula

$$\dot{R}\,\ddot{S}i + \dot{R}^3\,\ddot{A}l^2.$$

The European species Xanthophyllite and Disterrite are very nearly related to Clintonite; in all physical characters except color they are identical with it. Their chemical composition as given by Meitzendorf and v. Kobell is:

* Atomic weight of silicium = 21·3.

	$\ddot{S}i$	$\dot{A}l$	$\dot{M}g$	$\dot{C}a$	$\dot{F}e$	$\dot{N}a$	$\dot{H}$	
Xanthophyllite,*	16·30	43·95	19·31	13·26	2·53	0·61	4·33	*Meitzendorf.*
Oxygen,	8·65	20·53	7·72	3·77	0·56	0·15	3·85	
					$\dot{F}e$			
Disterrite,†	20·00	43·22	25·01	4·00	3·60	0·57	3·60	*v. Kobell.*
Oxygen,	10·61	20·20	10·00	1·14	1·08	0·10	3·20	

These differ from Clintonite in containing about 4 pr. ct. of water; if this be considered as replacing magnesia in the manner suggested by Scheerer the relation of the oxygen in the sesquioxyds and protoxyds is nearly 6 : 4; but the ratio 3 : 6 : 4 is not in accordance with the amount of silica obtained in the analyses. If the same replacement be allowed in Disterrite and the iron be assumed to exist as protoxyd, the oxygen ratio will be—

$\ddot{S}i$	$\ddot{R}$	$\dot{R}$
16·61 :	20·20 :	13·20

or almost exactly 3 : 6 : 4.

From these remarks it seems likely that the three species may all be brought under the general formula $\dot{R}\,\ddot{S}i + \dot{R}^3\,\ddot{A}l^2$ = Silica 19·19, alumina 43·54, lime 11·86, magnesia 25·41.

Munich, August 7th, 1854.

Note by J. D. Dana.—It is important to note that the ratio between the oxygen of the protoxyds and peroxyds together and that of the silica (the water being disregarded), is the same for Clintonite and Disterrite. We thus obtain—

	$\dot{R}+\ddot{R}$		$\ddot{S}i$		
1. Clintonite, . . .	32·02	:	10·74	=	3 : 1·06
2. " . . .	32·07	:	10·69	=	3 : 1
3. Disterrite, . . .	32·50	:	10·61	=	3 : 0·98

corresponding each to the ratio 3 : 1. This therefore appears to be the fundamental ratio of the species. We here take the iron in Disterrite as peroxyd, as published by von Kobell, which is its condition in Clintonite; this gives for the oxygen of the protoxyds and peroxyds the ratio 11·24 : 21·26. The formula $(\dot{R}^3, \ddot{R})\,\ddot{S}i^{\frac{1}{2}}$ expresses the ratio 3 : 1. In the Clintonite, $\dot{R}^3$ is to $\ddot{R}$ as 2 : 3; in the Disterrite nearly as 1 : 2. Expressing the ratio 2 : 3 for the Clintonite, this formula becomes $(\frac{2}{5}\dot{R}^3 + \frac{3}{5}\ddot{R})\ddot{S}i^{\frac{1}{2}}$.

If we regard one-third of the peroxyd in Mr. Brush's analysis as replacing silica, the oxygen ratio for $\dot{R}$, $\ddot{R}$, $(\ddot{S}i)$ becomes 12·78 : 12·86 : 17·12, or between the bases and the rest 25·64 : 17·12 = 3 : 2, giving the formula on page 129 of this volume

$$(\tfrac{1}{2}\dot{R}^3 + \tfrac{1}{2}\ddot{R})\,(\ddot{S}i, \ddot{A}l)^{\frac{2}{3}}.$$

* The mean from four analyses by Meitzendorf, from the 1st Supplement of Rammelsberg's Handw. Min., p. 158.

† Jour. für prakt. Chem., xli, 156.

ART. XLIV.—*Contributions to Mineralogy;* by Dr. F. A. GENTH of Philadelphia.

1. *Pyrophyllite.*

THIS interesting mineral was reported by Prof. C. U. Shepard to occur near Crowder's Mountain in North Carolina; the exact locality in that state is however "Cotton Stone Mountain," Mecklenburg county. My specimens from this locality were not pure enough for analysis; I give therefore in the following only the results of the examination of the same mineral from Chesterfield District, S. C.

B.B. it exfoliates into a fan-like opaque white mass of more than twenty times its original bulk; fuses with great difficulty into a white blebby slag. The lustre of the N. C. specimens is pearly; that of those from S. C. inclining to greasy.

The following are the results of my analyses:

Silica,	64·82	66·01
Alumina,	28·48	28·52
Sesquioxyd of iron,	0·96	0·87
Magnesia,	0·33	0·18
Lime,	0·55	0·23
Water,	5·25	5·22

2. *Chrysotile.*

The beautiful fibrous mineral of a yellowish white color and silky lustre, which occurs in small veins in serpentine at Abbottsville, N. J., has been examined by Mr. Edwin L. Reakirt.

B.B. it whitens, becomes brittle and fuses with difficulty into a white slag; with cobalt solution, flesh-colored. It contains:

Silica,	42·52	42·72
Alumina,	not det.	0·38
Sesquioxyd of iron,	not det.	0·30
Magnesia,	42·35	42·99
Water,	14·31	14·18

3. *Scolecite.*

Lyman Wilder, Esq., of Hoosick Falls, N. Y., kindly furnished me with the material for analysis of a mineral from the East Indies. It consisted of globular masses 5 to 6 inches in diameter of a radiated structure. Sometimes there was found between the radii, which have a vitreous lustre, the same mineral of a reticulated structure with pearly lustre.

B.B. it fuses with intumescence easily to a blebby glass. Mr. Wm. J. Taylor analyzed it and found it to contain:

Silica,	46·87
Alumina,	25·32
Lime,	13·80
Soda,	0·45
Potash,	0·13
Water,	13·46

4. *Owenite identical with Thuringite.*

In a previous paper (Am. Journ. Sc., 2d Series, vol. xvi, p. 165), I described a mineral from Harper's Ferry, Va., under the name "*Owenite*" as *new*, remarking, however, that the difference between it and Thuringite could be detected *only* by a chemical examination. I was unable at that time to obtain any genuine Thuringite for a comparative analysis, and, I must confess, I had *too much* confidence in Prof. Rammelsberg's analysis, to think it would need a repetition, since the difference was about 16 pr. ct. of alumina. In the meantime Prof. J. L. Smith, (Am. Journ. Sc., 2d Series, vol. xvi, p. 131), announced the identity of Owenite and Thuringite, but, the material for his analysis, as he told me, having been slightly altered by oxydation, it was desirable to reëxamine the fresh mineral. Jos. A. Clay, Esq., with the greatest liberality permitted me to take from his specimen a sufficient quantity for analysis. The original label of Dr. Krantz of Bonn, which was still with it, gave the locality "Schmiedeberg near Saalfeld in Thuringia." The material for the following analyses made by Mr. Peter Keyser, was not in the least degree altered, and the results, which he obtained show the identity in composition of Thuringite and Owenite, which latter name I therefore withdraw. For comparison I give besides the analyses of the Thuringite from Schmiedeberg also that of the same mineral from Harper's Ferry, Virginia (the Owenite).

	I.	II.	III.	IV.	V.
	From Schmiedeberg.				From Harper's Ferry. (Owenite.)
Silica,	24·36	23·09	23·19		23·21
Alumina,	15·69	15·86	15·34		15·59
Sesquioxyd of iron,	13·03	14·31	14·03		13·89
Protoxyd of iron,				34·20	34·58
Magnesia,	1·26	1·29	1·87		1·26
Lime,	0·00	0·00	0·00		0·36
Soda,	*trace*	*trace*	*trace*		0·41
Potash,					0·08
Water,				10·57	10·59

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the so-called Benzoëoxyd and some other conjugate compounds.*—List and Limpricht have studied the crystalline body obtained nine years since by Ettling and Stenhouse by the dry distillation of benzoate of copper, and which has been supposed to have the formula $C_{14}H_5O_2$. The authors found for pure and well crystallized substances the formula $C_{13}H_5O_2$, which agrees well with the analyses of Ettling but not with those of Will, Stenhouse and Gerhardt. This formula being doubled becomes $C_{26}H_{10}O_4$ or $C_{12}H_5O+C_{14}H_5O_3$, and the reactions clearly shew that the body in question is really the benzoate of oxyd of phenyl. An aqueous solution of caustic potash does not decompose the benzoate of phenyl when boiled with it under atmospheric pressure, but when heated to 150°–170° in a closed tube with a concentrated solution of the alkali the benzoate is dissolved, and when the solution is saturated with sulphuric acid, benzoic acid separates and an oily body rises, easily recognized to be phenyl-alcohol or carbonic acid. An alcoholic solution of caustic potash readily decomposes the benzoate, yielding of course the same products. Heated in a closed tube with ammonia the benzoate yields benzamid and carbolic acid. Bromine acts readily upon the benzoate of phenyl yielding products of substitution in which 1, 2, and 3 equivalents of hydrogen are replaced by as many of bromine. Decomposition of these compounds with caustic potash proves that it is the hydrogen of the oxyd of phenyl alone which is replaced and not that of the benzoic acid. Chlorine acts in a similar manner. A cold mixture of 1 part of nitric acid and 2 parts of sulphuric acid converts the benzoate of phenyl into a yellow crystalline body in which 3 equivalents of hydrogen are replaced by 3 of NO_4: in this case, however, the decomposition with caustic potash shews that 1 eq. of hydrogen is replaced in the benzoic acid, and 2 eq. in the oxyd of phenyl. Setting out from the theory that many organic bodies now regarded as aldehyds, &c., are in reality ethers, and have twice the equivalent usually attributed to them, the authors point to the fact that Ettling's Parasalicyl is a compound of anhydrous benzoic and anhydrous salicylous acids, and further that oil of bitter almonds and cuminol are both ethers and not aldehyds, since the former yields with an alcoholic solution of potash, benzoic acid and benzoic alcohol; the latter cuminic acid and cuminic alcohol.—*Ann. der Chemie und Pharmacie*, xc, 190.

2. *Researches on different questions in Organic Chemistry.*—Strecker has communicated to the Academy of Sciences in Paris a memoir with this title, containing the solution of several important questions. We shall give the principle results of these investigations under separate captions.

Composition of tannic acid.—Strecker finds that pure tannic acid is represented by the formula $C_{54}H_{22}O_{34}$, and that in this formula 3 eqs. of water are basic, so that the anhydrous acid is $C_{54}H_{19}O_{31}$. The lead salts of tannic acid contain from 3 to 10 eqs. of oxyd of lead.

The combinations of tannic acid with sulphuric and chlorhydric acids mentioned by Berzelius are in reality mechanical mixtures and are not constant in composition. The splitting of tannic acid into gallic acid and glucose, discovered two years since by Strecker, may be represented by the equation $C_{54}H_{22}O_{34}+8HO=3(C_{14}H_6O_{10})+C_{12}H_{10}O_{10}$. Gallic acid, according to Strecker, is also a tribasic acid and is represented by the formula $C_{14}H_3O_7+3HO$.

Decomposition of brucine by nitric acid.—The action of nitric acid upon brucine has been studied by Laurent, Gerhardt, Liebig and Rosengarten, but the products of this action have never been satisfactorily ascertained. Strecker finds that these products are cacotheline, nitrite of methyl, oxalic acid and water. The reaction is represented by the equation

$C_{46}H_{26}N_2O_8+5NO_5.HO=C_{40}H_{22}N_4O_{18}+C_2H_3O,NO_3+2C_2O_3,HO+4HO$.

The constitution of cacotheline was determined by means of its platinum salt; Laurent assigned to it the formula $C_{42}H_{22}N_4O_{20}$.

Hydrocyanaldin.—When a mixture of aldehyd-ammonia, prussic acid and an excess of muriatic acid are allowed to stand for some days without heat no alanin is formed, but colorless crystals of a new body which Strecker terms cyanaldin, are deposited. It is neutral, insipid, insoluble in water, alcohol and ether; it fuses and sublimes at a moderate heat; potash decomposes it with evolution of ammonia. The formula of this body is $C_9H_6N_2$ or $C_{18}H_{12}N_4$; it does not appear to possess basic properties.

Production of propionic acid in fermentation.—In preparing lactic acid by the fermentation of sugar by Bensch's process, Strecker observed that when the temperature of the mixture was kept low for several months, large quantities of mannite were formed. A mixture which deposited crusts of lactate of lime was abandoned during several months in summer in a place where the temperature did not exceed 22° C., the water being renewed from time to time. The volatile acids formed being isolated proved to be propionic and acetic acids, both in very large quantity.

3. *On some combinations of hydrargyro-methyl and hydrargyrethyl.*—The researches of Frankland on the compounds of methyl and amyl with mercury are well known. Strecker has succeeded—and without any knowledge of Frankland's experiments—in preparing the corresponding compound of mercury and ethyl, by simply exposing a mixture of mercury and iodid of ethyl to diffuse light at ordinary temperatures. After some time, crystals are formed which increase till the whole liquid becomes solid. The crystals are readily recrystallized from boiling ether or alcohol, and separate in thin, colorless very brilliant laminæ. They sublime at 100° C., but fuse only at a higher temperature: they are insoluble in water but soluble without decomposition in ammonia and solution of caustic potash. The formula of these crystals is $C_4H_5.Hg_2I$. The nitrate crystallizes in colorless prisms and is represented by the formula C_4H_5O,NO_5. The chlorid corresponds to the iodid. These compounds are all decomposed by light, which is the reason why Frankland could not obtain them.

Constitution of quinine.—Strecker has at length established the constitution of this important base, and finds it to be represented by

$C_{40}H_{24}N_2O_4$, which is precisely double the formula of Liebig. The nitrate is represented by the formula $C_{40}H_{24}N_2O_4, HO.NO_5$; the two sulphates are $C_{40}H_{24}N_2O_4, HO.SO_3$ and $C_{40}H_{24}N_2O_4, HO.SO_3 + HO, SO_3$. A mixture of iodid of ethyl and quinine dissolved in ether give crystals of iodid of ethyl-quinine or iodid of quinine in which 1 eq. of hydrogen is replaced by 1 eq. of ethyl; iodid of methyl produces a similar iodid of methyl-quinine; both these compounds are powerful bases. The author concludes that ethyl-quinine belongs to Hofmann's fourth class of bases and corresponds to ammonium NH_4. Quinine is itself a nitrid base or an ammonia, and contains in its molecule 3 compound radicals replacing hydrogen.

Artificial production of oil of cinnamon.—Strecker shewed some years since that styrone is the alcohol of cinnamic acid; he now finds that it may be readily transformed into its aldehyd by the action of air and platinum black. This aldehyd is pure oil of cinnamon.

Artificial production of taurine.—After several unsuccessful attempts, Strecker has succeeded in producing this remarkable body by heating isethionate of ammonia to a temperature of 230°, until the salt has lost 11 per cent. of its weight. The reaction is represented by the equation

$$NH_4O.C_4H_5O.2SO_3 = C_4H_7NO_6S_2 + 2HO.$$

The fused mass dissolved in water, precipitated by alcohol and then redissolved in water, gave large crystals identical with the taurine obtained from the bile.—*Comptes Rendus*, xxxix, 49, *July*, 1854.

4. *Contributions to the chemical history of Glucina.*—Weeren has published an investigation of glucina, which, although simply introductory to a more extended study of the salts of this metal, contains many interesting results. The author first examined the different methods which have been proposed for the separation of glucina from alumina. The result of this examination shewed that glucina cannot be completely separated from alumina either by means of carbonate of ammonia, caustic potash, sulphurous acid, or carbonate of baryta. Berzelius's method, by means of sal-ammoniac, is the only process which can be relied upon. In the execution of the separation by this method, however, the auther found it necessary to observe the following precautions. 1. To precipitate the two earths with ammonia after adding a very concentrated solution of sal-ammoniac. 2 To boil the mixture a long time. 3. To avoid too great an evaporation of the liquid. 4. To precipitate the glucina with sulphid of ammonium. The author considers the hydrate of glucina to be $G_2O_3 + 3HO$, though it is very readily decomposed, and loses a portion of its water at 110°, which renders its analysis very difficult. The numerous analyses of the carbonates of glucina lead to very improbable formulas, apparently either from their instability, or because the carbonates are mechanically mixed with variable proportions of hydrate. The sulphate of glucina has the formula $G_2O_3, 3SO_3 + 12HO$ as given by Awdejew; it loses 11 eq. of water between 100° and 110° C. but retains the 12th till a much higher temperature. The author has redetermined the equivalent of glucina by the careful analysis of the sulphate, and finds as a mean of five determinations the number 157·64, if we consider the glucina as GO, or 472·90 if we consider it G_2O_3. He prefers, however, the mean

between his own results and those of Awdejew, and considers therefore the equivalent of the metal 86·50—taking glucina as G_2O_3, or 57·68 taking glucina as GO.—*Pogg. Ann.*, xcii, 91. W. G.

5. *On a new Test for Zirconia;* by G. J. Brush, (J. f. pr. Chem., lxii, 7, 1854.)—In a recent examination of some American minerals, one of them regarded as rutile was decomposed by fusion with caustic potash, the fused mass dissolved in diluted hydrochloric acid, and the solution boiled with tin. Finding no reaction for titanium, the solution was tesfed with turmeric paper to ascertain whether it were alkaline or not. The paper was immediately colored orange-red. On dissolving a portion with still more acid, the same color was obtained, although with litmus paper the solution afforded an acid reaction.

On further analysis the mineral proved to be zircon, and it was found that the orange color was due to zirconia. To try the delicacy of the test, different zirconia minerals were examined, as zircons of Ceylon, the Ural and New York, Eudialyte, Wöhlerite and Catapleiite, and they all gave the orange color. Acid solutions containing the alkaline earths, alkalies, manganese, iron, zinc, tin, but not zirconia, were tested with turmeric paper, but no reaction was obtained except from a strong solution of sesquichlorid of iron, which in consequence of its own deep color discolored the paper. This may be avoided by reducing this chlorid to the protochlorid. An acid solution containing all but two of the above-mentioned substances, with a large excess of iron was reduced by tin. The solution gave no reaction with turmeric paper; but on adding a small portion of zirconia the color of the paper became orange-red. The presence of boracic acid wholly disguises that of zirconia. A known zirconia compound (a hydrate) was dissolved in hydrochloric acid and diluted with 3000 parts of water. The solution gave the deep orange-red color of zirconia; with 2000 parts more of water, the action was still distinct.

It appears therefore that turmeric paper is a simple and characteristic test of the presence of zirconia in an acid solution, when boracic acid is not present; if the solution is a very weak one, the paper should be left in it from half to one minute. It is to be observed that the solution should not be so acid that the acid itself will act on the paper and discolor it.

6. *On the Electricity of the Atmosphere;* by M. L. Palmieri, (Bib. Univ. Genève, xxvi, 1854, 105.)—M. Palmieri shows that the method of ascertaining the electrical condition of the atmosphere by the two ordinary methods, a fixed conductor, and a moveable electroscope (Peltier's method,) are unsatisfactory. The latter will often show indications when none is perceived with the former; and is also itself uncertain from difficulties of manipulating or the influence of the observer. M. Palmieri proposes therefore a new method by means of *a moveable conductor;* it is in use under the direction of the king of Naples at the Meteorological Observatory of Vesuvius at a height of 590 metres above the sea-level. The conductor extends above the roof of the building, and is arranged so as to be raised or depressed at will; its connections are of a nature to insulate it; and in the room below, it connects with an electroscope or other instruments as desired.

On elevating the conductor, the electric tension is measured by an electroscope; it is ascertained whether it be positive or negative by an electroscope of Bohnenberger; and in case of electricity in a dynamic state, a galvanometer may be connected with it by one wire whilst the other passes to the soil. An ordinary fixed conductor gives no indications if the earth and space about it are in equal electrical states, the condition then being one of equilibrium: But with Palmieri's arrangement, the conductor is raised, and the influence of the superior atmospheric beds become predominant; the electrometer will indicate tension according to the vertical distance passed through and the efficiency of the opposite electricities. Moreover the fixed conductor if there is much rain, is discharged as rapidly as the electricity is received; while the moveable conductor charges itself much more rapidly and gives decided indications.

M. Palmieri has ascertained some points of interest respecting atmospheric electricity.

He has verified on some serene days a diurnal periodicity in the electricity, as remarked by Schubler and others.

He finds that the interior even of storm clouds is always positive, except during the shock of lightning, or in the case of rain, hail or snow. In case of a rain storm commencing a long distance from the place of observation, and carried over this place by the wind,--he observes that when the storm is far off the electricity is positive, gradually increasing with the progress of the storm; when the storm comes near, the electricity is strongly negative, often producing sparks. When the rain has reached the place of observation, it is again positive; then strongly negative just after it passes, and finally positive, its usual condition. Between each period there is a momentary neutral point. The distance at which the rain begins to induce *negative* electricity is very variable, sometimes at 30 miles, and other times when the first drops begin to fall. The rain hence occupies a region charged with positive electricity surrounded by a zone of negative electricity. When there are several successive showers of rain, these results will be much complicated. Hence the idea of negative or neutral rain storms must be abandoned; negative clouds do not exist, and negative electricity is found in the atmosphere only in case of rain, hail or snow. During these three periods the effects are vastly the most energetic.

7. *A Vacuum made by Chemical means;* by M. C. Brunner.—The method is that by means of carbonic acid. The process is as follows: A tubulated bell glass is placed on a plate of ground glass, over a dish of sulphuric acid, above which acid on a support there is some quicklime; the bell glass is then filled through the tubulure with carbonic acid, the tube supplying this gas reaching to the bottom of the bell glass; after the atmospheric air is thus excluded, the tubulure is hermetically closed by a stopper through which passes a tube having a bulb containing water at the exterior end, while the interior extremity is near the lime. There is no action of the lime while it is dry, but on warming the bulb, water falls on the lime, and soon after, the carbonic acid is absorbed, while at the same time the moisture is taken up by the sulphuric acid.

Ammonia may also be employed, with some modifications of the process.—*Bib. Univ. de Gen.*, xxiv, 164.

II. Mineralogy and Geology.

1. *Contributions to Mineralogy;* by James D. Dana.—The following are figures of crystals of some species of American minerals.

Figs. 1, 2, *Compound Crystals of Copper Glance.* In fig. 1, composition is parallel to *I*, or the prism of 119° 35′; also parallel to $2\breve{i}$, producing thus a cruciform twin with the angle of intersection 125° 28′. In fig. 2, the composition is parallel to a face $\frac{1}{2}$, and the prisms cross at angles of 92° 5′ and 87° 55′.

Fig. 3, *Pyrites*, a crystal from Rossie, New York, in the cabinet of W. T. Vaux, Esq., of Philadelphia. The crystal is nearly an inch in diameter, and is peculiarly fine, although the surfaces, while very smooth, are not polished.

Fig. 4, *Mispickel* (Danaite). From a crystal in the cabinet of the late J. E. Teschemacher of Boston. It presents the unusual planes $1\bar{2}$, 3, and $3\frac{3}{2}$. It is from Franconia, New Hampshire.

Figs. 5, 6, *Quartz.* Figure 5 represents crystals from Quebec, furnished the author for examination by Mr. T. S. Hunt. They were from a half to three-fourths of an inch in length. The planes $-\frac{1}{2}$ are delicately etched, being covered with small triangular prominences, whose sides are parallel to the basal and two terminal edges of the plane $-\frac{1}{2}$. The other faces were shining. Other crystals from the same place were the inverse of that figured. Fig. 6 is taken from a slender crystal about one-eighth of an inch long, in the cabinet of J. E. Teschemacher. The narrow plane $-\frac{1}{2}$ instead of being plane, is excavated through its length with a neat triangular channel bordered by a sharp edge. The planes 22 and $3\frac{3}{2}$ are hardly separated by a well-defined edge, and are somewhat uneven in surface. The other planes are bright. The inclination of $\frac{3}{3}\frac{3}{3}$ on R gave on measurement 175°.

Figure 7, *Pyroxene.* A fine grass-green crystal an inch long with bright surfaces, from Long Pond, New York.

Figure 8, *Spodumene.* This is a new figure of the same crystal before roughly drawn by the author. The planes −22 and x appear to be hemihedral: but whether this is an accidental distortion or not is uncertain.

Figure 9, *Babingtonite?* The figure represents small polished black crystals occurring in mica slate at Athol, Massachusetts, referred to Babingtonite by Prof. C. U. Shepard. The form is triclinic, and the following are approximately the angles:

$O : I = 90°\text{–}91°$,	$I : I = 110°\ 30'$ and $69°\ 30'$.
$O : I = 85°$,	$I : i\breve{3} = 129°$.
$O : \frac{1}{2}' = 153°\ 20'$,	$I : i\breve{3} = 120°\ 30'$.
$O : -1 = 135°\ 40'$,	$I : \frac{1}{2}' = 95°\ 30'$.
$O : 1 = 135°\ 30'$	$O : i\breve{3} = 95°\ 30'$.

It resembles Epidote, and it is possible, that O, $\frac{1}{2}'$ and I, correspond respectively to O, $\frac{1}{2}i$ and $2i$ in Epidote.

Figure 10, *Zircon*, from McDowall Co., North Carolina. The crystals are found in the sands of the Gold region, and are seldom over a sixth of an inch in length.

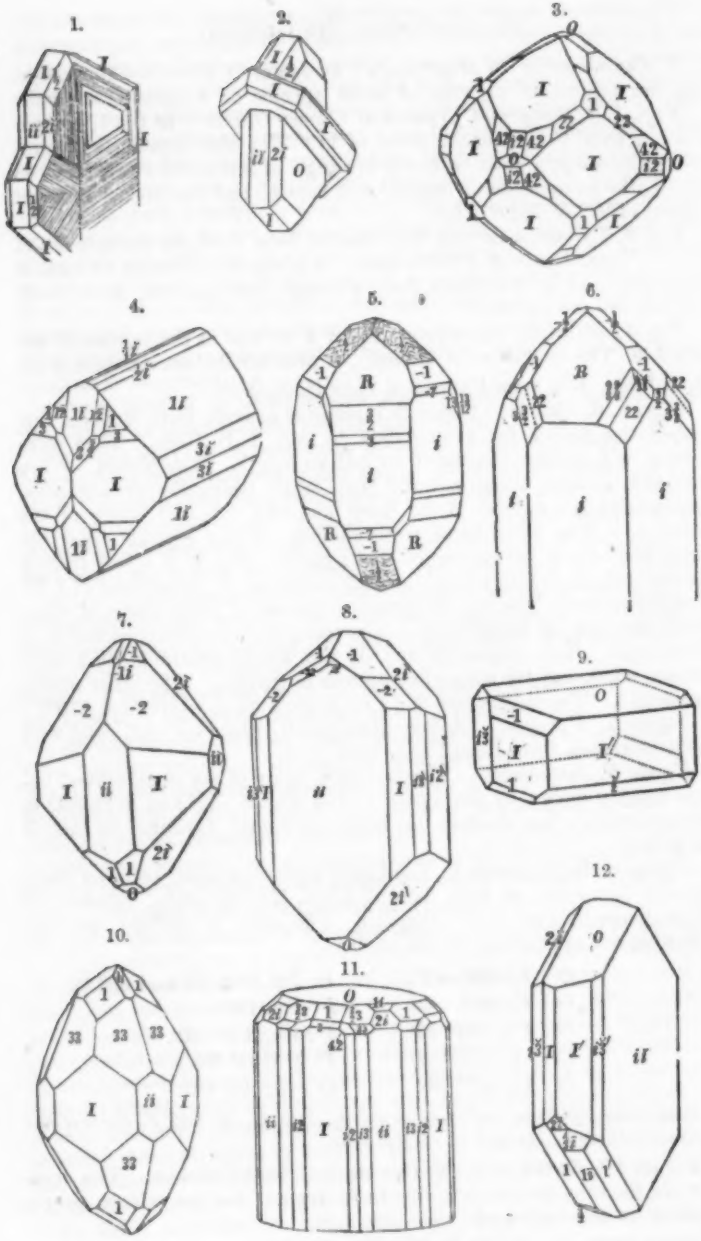

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Figure 11, *Idocrase.* From a crystal from Sanford, Maine, furnished the author by L. Stadtmuller. It is nearly half an inch in diameter, and the faces are all bright. The Idocrase occurs massive or subcolumnar at that place, and there are often cavities of fine crystals. The crystals are sometimes thinly sprinkled over with dark green crystals of pyroxene, hardly a line long, which are loosely attached to the idocrase and are evidently of subsequent origin, apparently a result of its alteration. The crystals of idocrase undergo ready alteration, and often the surface peals off in layers, over the whole summit; and the alteration has proceeded inward with such exactness that the removed layer leaves behind the same number of small secondary planes as in the complete crystal, and all equally brilliant in polish. This is the more wonderful since there are no cleavages parallel to all or any of these small secondary planes. The color of the idocrase is brown and greenish-brown. In one specimen having a columnar structure, the columns along a straight line two inches in length met at an angle of 56° to 60°, indicating composition parallel probably to the plane $4\breve{i}$.

Figure 12, *Albite* from the Middletown feldspar quarry. The crystals are half to one inch long, and in part transparent. They are mostly in twins parallel to $i\breve{i}$, but so united that the plane O and $1\bar{i}$ are in the same plane nearly. From one crystal the author obtained for $O : i\breve{i}$, 92° 40′ and 87° 20′.

Figure 13. The so-called *Loxoclase* from Hammond, St. Lawrence Co., N. Y., a feldspar shown by Smith and Brush to be orthoclase. The crystals are an inch long or larger, and of a nearly white color.

Figure 14. *Topaz* from Trumbull, Ct. The crystal is transparent and a fourth of an inch in diameter. The most of the terminal planes are rough.

Figures 15, 16, 17, *Tourmaline.* Figure 15 represents an upper view of the termination of a slender transparent crystal of a light yellowish color, from London Grove, near Unionville, Pennsylvania. It is from the cabinet of T. F. Seal, of Unionville. Figure 16 is from a black crystal one inch in length from Northern New York. Fig. 17 is a brown tourmaline from Canada, received from T. S. Hunt of the Geological Commission, Canada. R is the rhombohedron of 103°.

Figure 18, *Apophyllite* from the Cliff mine, Lake Superior region, Michigan. The crystals are from one-fourth to half an inch in length and transparent. They are generally tabular, but occasionally octahedral. The plane $i3$ is not the prism usually noted on crystals of this species.

Figures 19, 20, *Barytes* or Heavy Spar.—Figure 19 represents a crystal from Cheshire, Conn.; figure 20, one from the Eldridge gold mine, Buckingham Co., Va., sent the author by Dr. F. A. Genth. The size varies between one-fourth and three-fourths of an inch. All the planes but the striated vertical planes are highly polished. The terminal face is often cavernous, the polished plane O being often finished at different elevations short of the actual summit of the crystal.

Figures 21, 22, 23, *Anglesite*, from different crystals from the Wheatley mine, Phœnixville, Pa., furnished the author by the proprietor, C. M. Wheatley. The crystals present the same planes nearly, but are elongated in different directions. They are brilliant, glassy, often transparent, and sometimes an inch or more in length.

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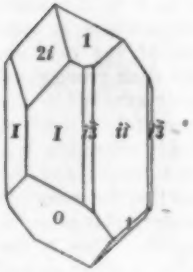

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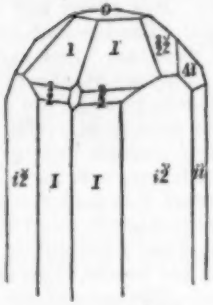

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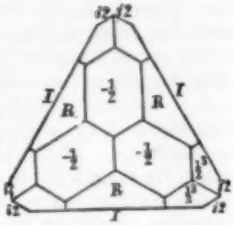

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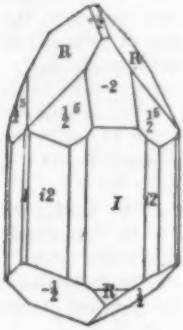

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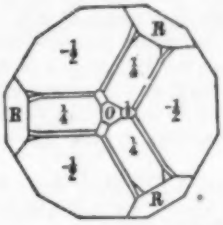

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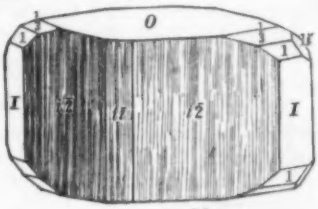

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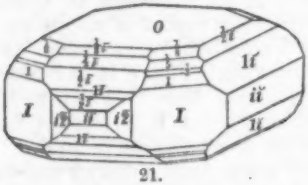

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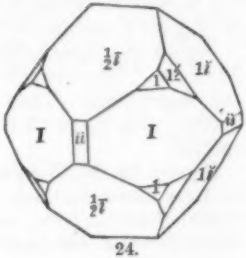

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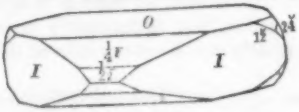

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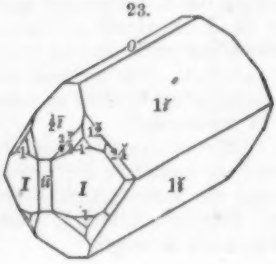

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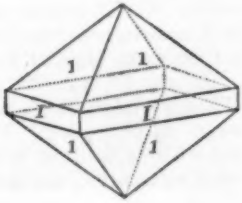


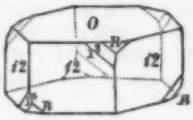
Figure 24. *Xenotime*, from Clarksville, Georgia, from crystals received from Prof. Lewis R. Gibbes, of Charleston, South Carolina.

Figure 25. *Calcite.*—From the Copper mine, Bristol, Connecticut. The crystals are implanted thickly over the rock, and are about half an inch long. The six-sided prism after a gradually accumination to a three-sided summit by oscillation with a scalenohedral form, (probably 1^3,) is subsequently terminated by a crystal of the nail-head form, making literally a nail-head crystal. The planes of the summit are the rhombohedral $-\frac{1}{2}R$.

25.

Figure 26. *Dolomite*, from Hoboken, New Jersey. The crystals are glassy, a third to a quarter of an inch across, and occur in cavities in massive dolomite.

26.



2. *Beiträge zur Kenntniss der Eisenhohofen-Schlacken, nebst einem geologischen Anhange*, (on Iron Furnace Slags, etc.); by J. F. L. Hausmann. 102 pp. 8vo. (From Studien des Gött. Ver. Bergm. Freunde.) Göttingen, 1854.—Prof. Hausmann has contributed largely to our knowledge of the slags of furnaces, and presented the bearing of the subject on the origin of minerals. This recent paper contains descriptions and analyses of various furnace products, and an application of the facts to Geology.

(1.) *A slag called Kieselschmelz* (Siliceous Enamel).—This slag is described by M. Koch, (Beit. zur Kenntniss kryst. Hüttenprodukte, Göttingen, 1822, 8vo, p. 40–81). It occurs in 6-sided prisms, tabular or elongated, with the terminal edges sometimes removed, producing rarely a six-sided pyramidal termination. Color whitish, gray, yellowish, brownish, greenish. G.=2·72. H.=·7. Translucent, to subtranslucent. Lustre waxy, weak. Crystals sometimes glassy at centre.

Analyses of specimens from iron-furnaces: 1, 2, by A. Knop, different specimens of same slag from the Hartz; 3, Dr. Limpricht, another slag from the Hartz; 4, Knop, from Neuwerk, of the Brunswick Hartz:

	1.	2.	3.	4.
Silica,	55·78	59·45	54·27	55·41
Alumina,	15·28	15·43	9·40	11·52
Lime,	29·21	25·12	29·30	28·10
Magnesia,	——	——	1·15	1·89
Protox. iron,	—— =100·27	—— =100	6·58=100·70	3·08

Analyses 2, 3, and 4, give for the oxygen ratio of $\dot{R}$, $\ddot{R}$, $\ddot{S}i$,

2,	7·18 : 7·21 : 31·50 = 1 : 1 : 4 (nearly).
3,	10·29 : 4·39 : 28·75 = 2·34 : 1 : 6·55
4,	9·47 : 5·38 : 29·20 = 1·76 : 1 : 5·43

These ratios afford for the oxygen of all the bases and the silica the ratio nearly of 1 : 2, which is characteristic of both pyroxene and beryl; Hausmann deduces the formula $\dot{C}a^3\ddot{S}i^2+\ddot{A}l\ddot{S}i^2$, and points out the close similarity to beryl, if glucina be taken as a protoxyd, the difference

being that lime here replaces the glucina. Analysis 2 affords very nearly this formula.*

The form is related to that of beryl. The inclination of the pyramidal planes on the lateral faces of the hexagonal prism according to Koch is 103° 15′ 46″, or on *O* (the base) 166° 44′ 14″. This plane referred to the beryl type is, the plane $\frac{2}{5}$.†

(2.) *Gehlenite Slag.*—Among the slags of iron furnaces, 4-sided rectangular prisms or tables are not uncommon. D. Forbes first pointed out a slag in 4-sided prisms which was near Humboldtilite. Hausmann has described similar slags. Rammelsberg refers a slag from Oldbury, England, described by Percy, to Gehlenite, it giving the composition $3\dot{R}^3\,\ddot{S}i + \dot{\ddot{A}}l^3\,\ddot{S}i$. A slag from near Homberg, analyzed by Bunsen has a similar constitution. It occurs in tabular or oblong prisms, of a pearl gray color, glassy or pearly lustre, sometimes translucent; G.=2·876, H.=6. B.B. in the forceps fuses with some difficulty to a grayish slag. Bunsen's analysis afforded

$\ddot{S}i$	$\dot{\ddot{A}}l$	$\dot{C}a$	$\dot{M}g$	$\dot{M}n$	$\dot{K}$	$\dot{N}a$
32·22	17·81	17·35	5·57	2·67	3·05	11·30=99·97

whence the formula $2\dot{R}^3\,\ddot{S}i + \dot{\ddot{A}}l^3\,\ddot{S}i$.

Rammelsberg has analyzed and described some slags from Mägdesprung in the Anhalt Hartz,‡ where the ores are spathic and specular iron and limonite. He obtained for the formula $\dot{R}^3\,(\ddot{S}i, \dot{\ddot{A}}l)^2$, adopting Scheerer's view that $3\dot{\ddot{A}}l$ replace $2\ddot{S}i$. This is similar to some aluminous pyroxenes. The crystallized and glassy slags gave the same composition. Both dimetric (Humboldtilite-like,) and augitic crystallizations occur at Mägdesprung, and it appears probable that the two are a case of dimorphism. Von Kobell formerly wrote for the formula of Gehlenite $\dot{R}^3\,(\ddot{S}i, \dot{\ddot{A}}l)^2$; and this is analogous to the formula of pyroxene.§

* The special formula above given is correct only for analysis 2. The general formula for the whole may be written $(\dot{R}^3, \dot{\ddot{R}})\,\ddot{S}i^2$, with which the results accord very closely, as Hausmann shows. It is the formula of the Augite Section of Silicates, and includes pyroxene and beryl, these species being dimorphous. The slags are very near *Wichtyne* in composition, which the writer has placed in the Augite Section and may be the same species; the formula for Wichtyne is the same as for No. 2, viz. $\dot{R}^3\,\ddot{S}i^2 + \dot{\ddot{R}}\,\ddot{S}i^2$; it differs mainly in containing protoxyd of iron in place of lime. The slags may therefore afford evidence that *Wichtyne* is hexagonal in crystallization.—J. D. D.

† It is also of interest to compare the form with that of Nepheline. In Nepheline $O : \frac{1}{2} = 166° 25\frac{1}{2}'$, which differs $18\frac{1}{2}'$ from the inclination of the pyramidal plane in the slag. It may be also noted that $O : \frac{1}{2}2$ in beryl is 165° 59½′.—J. D. D.

‡ Poggendorff's Annalen, 1848, lxxiv, 95, and Lehrbuch der Chem. Metallurgie.

§ The analyses of the Mädgesprung slags by Rammelsberg gave rather varying ratios. The per-centage of silica was about 40; and the ratio between the oxygen of all the bases and that of the silica, was nearly 3 : 4, instead of 6 : 4, the Gehlenite ratio. Rammelsberg deduces for the ratio between the oxygen of the protoxyds and that of the silica and alumina ($3\dot{\ddot{A}}l$ replacing $2\ddot{S}i$), 1 : 1·7, to 1 : 2·0; 1 : 1·83 is the mean of his results. For his formula, 1 : 2 is taken as the ratio.

Gehlenite has the oxygen ratio for $\dot{R}$, $\dot{\ddot{R}}$, $\ddot{S}i$, 3 : 3 : 4, which gives 6 : 4 or 3 : 2 for the oxygen of the bases and silica; while Humboldtilite has the oxygen ratio 6 : 3 : 9, corresponding to 1 : 1, between the bases and silica, thus differing widely from Gehlenite. The formula of Gehlenite based on the ratio 3 : 2 would be

$(\frac{1}{3}\dot{R}^3 + \frac{1}{3}\dot{\ddot{R}})\,\ddot{S}i^{\frac{2}{3}} = \dot{R}^3\,\ddot{S}i^{\frac{2}{3}} + \dot{\ddot{R}}\ddot{S}i^{\frac{2}{3}}$, and that of Humboldtilite $(\frac{2}{3}\dot{R}^3 + \frac{1}{3}\dot{\ddot{R}})\,\ddot{S}i = 2\dot{R}^3\,\ddot{S}i + \dot{\ddot{R}}\,\ddot{S}i$.

There is as yet no good evidence that alumina replaces silica in Gehlenite. Pyroxene, Humboldtilite and Gehlenite appear rather to belong to different sections of silicates, the first, to the Augite, the second, to the Garnet, to which Scapolite pertains, and the third, to the Andalusite section.—J. D. D.

(3.) *Pyroxene Slag from Stolberg in the Hartz.*—The slag is part glassy and part enamel-like. The crystals are yellowish-white, with the lustre weak resinous; they are either 4 to 6-sided prisms or oblique octahedral. The form may be referred to the Augite type. The occurring vertical prism has the angle 115°, corresponding to $i\frac{5}{3}$ ($\infty P\frac{5}{3}$) of pyroxene. Analysis afforded M. Levi:

$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	S
42·75	9·09	2·77	4·64	38·19	0·74	0·39	0·73=99·30

Taking $3\dot{A}l$ as replacing $2\dot{S}i$, as Hausmann states, the oxygen ratio for the protoxyds and silica is nearly 1 : 2. The slag is related to those examined by Rammelsberg from Mägdesprung.

(4.) *Feldspar Slag from near Stolberg in the Hartz.*—This slag has a gray color and is part blebby and part crystalline. The crystalline slag has a massive base through which crystals are disseminated. The crystals are thin, long prisms, (about a line thick) and they appear to have a rectangular cleavage; color white, with a resino-vitreous lustre; G.=2·35; H.=6. B.B. fuses rather easily with much intumescence to a white translucent blebby glass. Insoluble in muriatic acid. Analysis gave:

$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$
66·2	10·4	1·9	0·1	21·0 = 99·6

giving the oxygen ratio for $\dot{K}, \dot{R}, \dot{S}i$, 6·44 : 4·86 : 35·07, which Hausmann observes corresponds nearly to $\dot{K}\,\dot{S}i + \dot{A}l\,\dot{S}i^3$, the formula of Orthoclase, from which it differs in containing lime in place of potash.*

(5.) *On the blue color of glassy slags.*—The author adopts the view of Fournet (Ann. des Mines, [4], ii, 57), that the cause of the blue color is not chemical. The green color of bottle glass changes to blue as the glass begins to pass to the condition of enamel or an earthy state; and the color is produced in this incipient stage by a new grouping of the minute particles of the mass. Another kind of blue slag, having lavender-blue to ultramarine or indigo-blue color, is supposed to derive its color (like ultramarine) from the presence of a trace of sulphur, as found on analysis.

After an enumeration of the crystalline silicates in slags, (1, Pyroxene species; 2, Gehlenite; 3, Humboldtilite; 4, Feldspar; 5, Chrysolite; 6, Beryl-like; 7, Chytophyllite,)† the author reviews the characters of the different varieties of slags, which he divides into, (I) the Crystalline Slags; II, Porcelain and Stony Slags; III, Glassy Slags; IV, Porphyritic (1, with the base crystalline; 2, with a porcellanous or stony base; 3, with a glassy base); V, Variolite Slag; VI, Blebby and Scoriaceous Slags; VII, Filamentous Slag; VIII, Capillary Slag; IX, Pseudomorphous Slag.

* This formula corresponds to the oxygen ratio 1 : 3 : 12, while the slag gives 1 : 0·75 : 5·45. The two are nearly alike in having for the oxygen ratio of the bases and silica 1 : 3. But from the shape of the crystals, the absence of the feldspar-habit, as well as the divergence from the feldspar oxygen ratio between the protoxyds and peroxyds (1 : 3), it seems probable that the slag is more nearly related to Edelforsite ($\dot{C}a\,\dot{S}i$ or $\dot{C}a^3\,\dot{S}i^2$) than to Feldspar. The formula may be $(\dot{C}a^3, \dot{A}l)\,\dot{S}i^2$, analogous to that of Edelforsite, in which $\dot{C}^3$ is to $\dot{A}l$ as 4 : 3.—J. D. D.

† See a notice of Hausmann's description of this species in this Journal, vol. xii, p. 394.

Hausmann next compares the specific gravity of certain slags in the stony and glassy states. He then proceeds to apply the subject to Geology, comparing the furnace products with volcanic ejections and other igneous rocks. The minerals of slags, pyroxene, chrysolite, feldspar, humboldtilite, are observed to characterise the Vesuvian lavas. He distinguishes between the volcanic, vulcanoidic and Plutonic rocks, the last never running into glassy forms and abounding in silica; the second kind an intermediate class between the volcanic and the Plutonic.

3. *Temperature of the interior of the Earth.*—An artesian well has been dug at Naples at the Royal Palace under the direction of MM. Melloni and Cangiano. The opening is about 20·98 meters above the level of the sea. After descending 15·2 meters, a volcanic tufa was reached which was 84 meters thick; at the end of December, 1845, they had gone beyond this 60 meters through different imperfectly aggregated volcanic materials, below which the engineer Cangiano expected to find the Jurassic formation, which extends from the Promontory of Castellamare and Nocera. M. Melloni ascertained that the temperature varied from 14°·6 to 15°·5 C. (58·3 to 60° F.) at 30 meters below the surface. It was 18°·3 C. (65° F.) at a depth of 190 meters, which gives an increase of 1° C. for 50 meters (or 1° F. for about 30 yards), a slower rate of increase than has elsewhere been observed, which Melloni attributes to the poor conductibility of volcanic tufa for heat. In a well sunk in the Tuscan marshes, the increase of temperature was 3 times more rapid.—*Atti del Instituto Veneto*, v, 234–237, and *Bib. Univ. de Genève, June*, 1854, 177.

4. *A System of Mineralogy, comprising the most Recent Discoveries:* including full Descriptions of Species and their Localities, Chemical Analyses and formulas, Tables for the Determination of minerals, with a Treatise on Mathematical Crystallography and the Drawing of Figures of crystals. Illustrated by six hundred wood-cuts. By JAMES D. DANA, Fourth edition, rewritten, rearranged and enlarged. 2 vols., 320 and 534 pp. 8vo. New York and London: Published by George P. Putnam & Co. 1854.—As a notice of the new edition of this work we cite here the Author's Preface.

In the Preface to the last edition of this Treatise, the classification of Minerals then adopted was announced as only a temporary expedient. The system of Mohs, valuable in its day, had subserved its end, and in throwing off its shackles for the more consistent principles flowing from recent views in chemistry, the many difficulties in the way of perfecting a new classification led the author to an arrangement which should "serve the convenience of the student without pretending to strict science."

A classification on chemical principles was however proposed in the latter part of the volume, in which the Berzelian method was coupled with crystallography, in a manner calculated to display the relations of species in composition as well as form, and prominently "exhibit the various cases of isomorphism and pleomorphism among Minerals." The progress of Science has afforded the means of giving greater precision and simplicity to this arrangement, until now it seems entitled to become the authorized method of a System of Mineralogy. Whether regarded from a physical or chemical point of view, the groupings ap-

pear in general to be a faithful exhibition of the true affinities of the species.

The mind uneducated in Science may revolt at seeing a metallic mineral, as galena side by side with one of unmetallic lustre, as blende; and some systems, in accordance with this prejudice, place these species in separate orders. Like the jeweller, without as good reason, the same works have the diamond and sapphire in a common group. But it is one of the sublime lessons taught in the very portals of Chemistry, that nature rests no grand distinctions on lustre, hardness, or color, which are mere externals, and this truth should be acknowledged by the Mineralogist rather than defied. Others, while recognizing the close relations of the carbonates of lime, iron, zinc and manganese, (calcite, spathic iron, smithsonite and diallogite,) or of the silicates of lime, iron, manganese, (wollastonite, augite, rhodonite,) are somewhat startled by finding silicate of zinc, or silicate of copper among the silicates of the earths or of other oxyds. But the distinction of "useful" and "useless," or "ores" and "stones," although bearing on "economy," is not Science.

The advantages which the arrangement of the last edition afforded those interested in mining and metallurgy, is secured in the present volumes by an index to the useful ores, in which their distinctive characters and their relative importance in the Arts are mentioned, and references are given to the pages where the full descriptions are to be found.

During the four years since the appearance of the last edition, the Science of Mineralogy has increased in species from 625 to 660; and this notwithstanding the bankruptcy of some 45 of the number. The important work of Rammelsberg on Chemical Mineralogy, has been continued in a fifth Supplement, issued in 1853. A similar review of the Progress of the Science by Dr. Gustav Adolph Kenngott, conducted with like thoroughness, though with less criticism, has appeared in Vienna, and already two large volumes have been issued, one reviewing the Science for the years 1844 to 1849, the other, for 1850 and 1851. During this period also, Professor Gustav Rose has published his Krystallo-chemische Mineral-System (1853); Professor von Kobell, a work on Mineralogical Nomenclature (1853), and a new edition of his excellent Tables for the Determination of Minerals, (1853); Dr. Franz Leydolt and Professor Adolf Machatschek, of Vienna, their Elements of Mineralogy based on the system of Mohs (1853); Dr. Kenngott of Vienna, "Das Mohs'sche Mineralsystem" (1853), and also a portfolio of plates of figures for the construction of Models of crystals (1854); Professor Quenstedt, of Tubingen, the first part of a Treatise on Mineralogy (1854); Dr. C. F. Naumann, a revised edition of his invaluable Elements of Crystallography (1854); Dr. Friederich Pfaff, of Erlangen, Elements of the Mathematical Relations of Crystals (1853); F. H. Schröder, of Clausthal, Dr. Rammelsberg of Berlin, and Jos. Pecirka of Prague, smaller Manuals on the same subject, (1852, 1853); Dr. J. Zimmermann of Stuttgard, a small "Taschenbuch der Mineralogie" (1852); Nicolai von Kokscharov, the able Crystallographer of St. Petersburg, the first numbers of his "Mineralogie Russlands," in quarto, (1853, 1854); H. J. Brooke and W. H.

Miller, a new and original Treatise under the title of Phillips's Mineralogy (1852); C. F. Plattner, an enlarged edition of his extended Treatise on the Blowpipe (1853): besides the great work of Dr. Gustav Bischof, on Chemical and Physical Geology, begun in 1846, now numbering 2950 pages, (the last issue in 1853), and yet wanting another part to be complete; also G. H. Otto Volger's Essays on the Development of Minerals, (Studien zur Entwicklungsgeschichte der Mineralien,) as the basis of Scientific Geology and a rational Mineral Chemistry, (Zürich, 1854); and von Waltershausen's Treatise on the Volcanic Rocks of Sicily and Iceland. Moreover, various valuable papers have been issued in Scientific Journals and Transactions abroad, by Haidinger, Rammelsberg, Breithaupt, Scheerer, von Kobell, Rose, Bunsen, Hermann, von Rath, Hausmann, Sandberger, Wöhler, Baer, Kenngott, Schabus, Kokscharov, Scacchi, Meneghini, Delesse, Damour, Deville, Descloizeaux, Senarmont, Chapman, Mallet, Scott, Percy, and other able investigators. In this country have appeared Part I. of the third edition of Prof. C. U. Shepard's Mineralogy (1852); Foster & Whitney's Report on the Geology and Mineralogy of the Lake Superior Region (1851 and 1853); and J. D. Whitney's Mineral Wealth of the United States (1854).* Moreover, Dr. J. Lawrence Smith and G. J. Brush, have labored with important results in American Mineralogy, clearing away many doubtful species; and other researches have been published by T. S. Hunt, F. A. Genth, J. C. Booth, J. D. Whitney, C. U. Shepard, J. W. Mallet, W. P. Blake, M. H. Boye and T. H. Garrett.

Of all these publications, Bischof's "Lehrbuch" stands first in importance. Mineralogy was well nigh a lifeless Science, having only powers of increase by accretion, like the objects of which it treats,—the addition of a new Mineral now and then being the great event of interest in its progress. Bischof, by his elaborate researches and profound views, has given it a new impulse. He makes every analysis of a Mineral an important element in the study of Mineral history, showing the necessity of their multiplication, and well exposing the leanness of Chemical formulas when given as a substitute for analyses. The associations and collocations of Minerals, their changes from exposure to atmospheric and other agencies, and even the infinitesimal ingredients in their constitution, are all made to bear on the question of the origin and progress of Mineral and Rock Formations. A Mineral species is shown to have a history of its own,—its perfect state, its liabilities to alteration and decay, its successive changes, and again its renovation or its metamorphosis into a new species. These views taken in their wide extent, constitute the proper basis of the Science of Geology, and should have their full exposition in a work on that Science. But the elements of the subject are with propriety indicated in a Mineralogical Treatise. While dwelling with deserved emphasis on the researches of Bischof, we should not forget that others have labored in the same department, prominent among whom, are Haidinger, Volger, Breithaupt, Blum, Bunsen and Delesse.

* Logan's Reports on the Geology of Canada, 1849–1853, should here be added, as they contain much that is valuable in Mineralogy as well as Geology.

The work next in importance, more especially in its bearing on the crystallization of Minerals, is the "Elementary Introduction to Mineralogy," by Brooke & Miller. It stands preëminent for its original measurements, and its thorough revision of the angles of Crystals, and will remain a permanent source of information on these points.

In the preparation of the present edition, the author takes pleasure in making special acknowledgements to the work of Bischof, for facts and principles relating to the Chemistry of the alteration of Minerals; to Rammelsberg's Supplement to his Chemical Mineralogy, a work whose earlier parts contributed largely to the preceding edition of this Treatise; to Kenngott's and Kokscharov's publications; and to the critical observations in the "Mineralsystem" of G. Rose. Frequent use has also been made of the work of Brooke & Miller, in the crystallography of the species, from which the angles and planes of crystals have often been cited. The various Scientific Periodicals of Russia, Germany, Italy, France and Britain, some of them down to June last, have been searched for their facts, and every effort has been made to post the work up to the day of publication.

American Mineralogy owes much to the careful revision it has received at the hands of Messrs. Smith & Brush; and the author would express his special personal obligations to each of these Chemists. From Dr. F. A. Genth, of Philadelphia, he has derived generous aid both in suggestions and results of researches. Mr. T. S. Hunt has kindly contributed several new analyses throwing much light on the minerals of Canada; and valuable observations and analyses have been received from J. D. Whitney and Professor Booth. Many and various have been the favors, in the way of new facts, opinions and récent discoveries, which the author owes to Mr. Louis Sæmann of Paris. He is also largely indebted to Robert P. Greg, Jr., of Manchester, England, for information respecting the Mineralogy of Great Britain, liberally furnished from a work by him and W. G. Lettsom, now in the press. * * * *

In the preparation of this edition, the subject of Crystallography has been revised and simplified. A system of notation for the figures of crystals, both brief and simple, has been adopted; and many new and original figures have been introduced. The homœomorphous relations of mineral species have been worked out with considerable care, in order to arrive at their true fundamental forms, and trace the bearing of the subject on their composition and classification. The Table of atomic weights has been corrected according to the most recent results, and the percentages of the formulas have been recalculated to correspond with it. The subject of pseudomorphs is treated at some length, and along with the descriptions of the species, a paragraph is devoted to the altered forms which each presents. These changes, together with the remodeling of the classification, and the large additions throughout, render the Treatise more properly a new work, than a revised edition.

5. *Lanthanite.*—Prof. J. Lawrence Smith, as an addition to his account of this species, on page 378, mentions that the specific gravity is 2·843, a little higher than the determination of W. P. Blake. Prof. Smith freed the mineral from air by boiling it and then using the air-pump.

III. Botany and Zoology.

1. *Victoria Regia; or the Great Water Lily of America; with a brief account of its discovery and introduction into cultivation; with illustrations by William Sharp, from specimens grown at Salem, Massachusetts, U. S. A.;* by John Fisk Allen. Boston, 1854.—This regal Water-Lily, whose gigantic size baffles the ordinary resources of the cultivator, was, as is well known, first raised and flowered in this country by Caleb Cope, Esq., of Philadelphia, who, aided by our sunnier climate, succeeded in giving the plant an ampler development than it had attained in England. Mr. Allen of Salem, a gentleman of great enthusiasm and success in cultivation, has the honor of having followed this example, and of flowering the *Victoria* last summer, for the first time in New England. By a skillful arrangement, Mr. Allen was able to bring the plant to great perfection in a tank of moderate size, the borders of which were enlarged from time to time as the successive leaves increased in magnitude. This year new plants have been raised in an ample tank constructed for the purpose, and already its huge blossoms are beginning to appear. Not content with thus rivalling the royal and princely conservatories of Kew, Syon, and Chatsworth, in the cultivation of the great Water Lily of the Amazon, Mr. Allen has now emulated Sir Wm. Hooker's magnificent work, illustrating the *Victoria* by colored figures mostly of the natural size, and in the highest style of art. Mr. Allen's treatise is an equally sumptuous work, of about the same gigantic size, the largest elephant folio, and the paper, typography and colored plates will compare favorably with the English work, except in the want of botanical details and dissections. Unsparing of expense, Mr. Allen has given six plates; while Sir Wm. Hooker has only four. And in 16 pages of text of the same huge dimensions, Mr. Allen has given a condensed abstract of the botanical history of the plant and of its introduction into cultivation in England, followed by a more detailed account of its cultivation into this country by Mr. Cope and himself, and a description of all its parts, as exhibited in the individual under his attentive observation. A. G.

2. *Plantæ Junghuhnianæ: Enumeratio Plantarum quas in Insulis Java et Sumatra detexit Fr. Junghuhn.* Fasc. III. (Leyden, 1854. pp. 271–394. 8vo.)—The excellent Dutch botanists are now very active, especially Prof. Miquel, Prof. De Vriese (who is still occupied with the elaboration of the Laurineæ for De Candolle's Prodromus), and Drs. Dozy and Molkenboer, who have worked up the *Musci Frondosi* (the Div. *Acrocarpi*) of Junghuhn's collection in the present fasciculus. Some new collaborators appear in the work: Among them M. Buse, who has elaborated the *Gramineæ*, and proposed several new genera; and Dr. Bruyn, who has given the *Polygonaceæ*. There are also the *Lycopodineæ* by Spring, and several small orders by Miquel. A. G.

3. *Steudel's Synopsis Plantarum Glumacearum:* fasc. III. comprises most of the *Agrostideæ* (with 171 species of Agrostis!), the *Arundinaceæ*, *Pappophoreæ*, *Chlorideæ*, and the greater part of the *Avenaceæ*. The work will be useful as bringing together the vast number of Grasses published since Kunth's Enumeration; but is of no more critical value than that work. A. G.

4. *Seemann's Botany of the Voyage of the Herald.*—Part V, finishes the *Compositæ* of the Flora of the Isthmus of Panama, and continues this flora down to the *Piperaceæ*, which, as well as the *Artocarpeæ*, are elaborated by Professor Miquel of Amsterdam, the able monographer of these families. Mr. Seemann has reëstablished the order *Crescentiaceæ*, with a new character, and referred to it nine genera and about thirty known species; all natives of tropical and subtropical America and Africa. His views were expounded last winter in a paper read before the Linnæan Society of London, when he divided the order into two sections, the *Crescentieæ* and the *Tanæcieæ*. In the September No. of Hooker's Journal of Botany, this author has given an able revision of the principal genera and species of the *Crescentieæ*. Among the plates are fine illustrations of the Ivory-Nut Palm, the *Phytelephas macrocarpa* of Ruiz and Pavon. A. G.

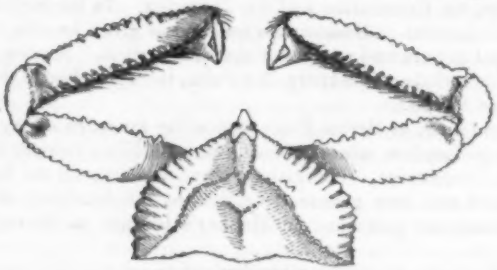
The *Pandaneæ*, or Screw Pines, are being investigated by Professor De Vriese of Leyden, who is about to publish Nova Genera Pandanearum, with illustrations. Meanwhile, some remarks on the family, and characters of two new genera, read before the Academy of Sciences at Amsterdam, are published in Hooker's Journal of Botany for September. A. G.

Three Botanists of considerable distinction have died during the past summer, namely, Dr. Fischer of St. Petersburgh, long the Director of the Imperial Botanic Garden, who deceased on the 5th of June, aged 73. M. Moricand of Geneva, the author of *Plantes Nouvelles d'Amérique*, also well known as a conchologist; he died June 26th. Philip Barker Webb, Esq., a distinguished English Botanist, long resident abroad, chiefly in Paris, where he will be greatly missed and deeply regretted, not only by all the French Naturalists, but by a wide circle of friends and correspondents, who will long remember his generous hospitality and kindness. He died suddenly, of cholera, on the 31st of August. Mr. Webb was an excellent classical scholar as well as a general naturalist. His most extensive work is the *Histoire Naturelle des Iles Canaries*, written in conjunction with M. Berthelot; almost every page of which reveals something of the vast and varied knowledge of Mr. Webb. Among his publications are the *Otia Hispanica*, a folio volume of plates and descriptions of Spanish plants; the *Spicilegia Gorgonea*, an account of the botany of the Cape de Verd Islands, contributed to Hooker's Niger Flora; and the *Fragmenta Florulæ Æthiopico-Ægyptianæ*, recently published. Mr. Webb had accumulated one of the largest private herbaria in the world. This, we learn he bequeathed to his "dear friend, the Duke of Tuscany." Its acquisition will render the Florentine herbarium,—the foundation of which was recently laid by his friend, the zealous Parlatore—one of first-rate importance.

To this list should be added the name of the late King of Saxony (recently killed by a fall from his carriage), one of the Foreign Honorary Members of the Linnæan Society of London, a botanist of much zeal and no mean acquirements. A. G.

5. *Description of a New Species of Cryptopodia from California;* by JAMES D. DANA.

CRYPTOPODIA OCCIDENTALIS. Rostrum parvulum, subspiniforme. Carapax postice rectangulatus, angulis postero-lateralibus acutis, margine postico rectiusculo, transverso, margine antero-laterali arcuato, lateralique denticulatis. Chelæ prælongæ, bene trigonæ, angulis tenuibus inæquè subspinulosis, manu latitudinem carapacis longitudine æquante, superficie supernâ planâ. Pedes 8 postici tenuiter compressi, articulis 3tio 4to 5toque bialato, tarso tenui, 4-alato. Long. 1″.



Cryptopodia occidentalis.

The carapax has a triangular sharp-edged prominence on the medial line behind the middle; a doubly curving subtuberculate ridge extending to the posterior angles; a small denticulate ridge, extending from near the middle to either side of the base of the beak, the two enclosing a narrow area. The breadth of the carapax is $1\frac{1}{4}$ inches, the length of the hand $1\frac{1}{8}$ in.; of the carpus 5 lines; of the arm 1 inch. The animal appears to have had when alive a villous coat over the carapax and upper surface of the hand. From Monterey, where it was obtained by Wm. Rich, Esq.

IV. ASTRONOMY.

1. *New Planets*, (Astron. Journ., 75.)—Mr. J. R. HIND announces the discovery of another asteroid, on the 22d of July, at $11^h\ 25^m$, at Mr. Bishop's Observatory in Regent's Park. It appears as a star of the 9·10 magnitude. Its position at that time was R. A. $21^h\ 10^m$ and N. P. D. 106° 20′. On the 1st of Sept., Mr. James Ferguson of the Washington Observatory discovered a new asteroid near *Egeria*, and nearly equaling it in brightness. The next day it preceded *Egeria* 24^s, and was 52″ farther North. Professor Reuel Keith has computed the following elements from the Washington observations of Sept. 2, 6, and 10. They satisfy the middle place perfectly.

Mean Equinox 1854.0 Epoch, Sept. 2·721 Greenwich M. T.

Mean anomaly,	13° 36′ 33″·3
Long. perihelion,	352 5 50 ·6
" asc. node,	33 29 21 ·7
Inclination,	22 39 13 ·6
Angle of excentricity,	4 22 30 ·2
Log. semi-axis major,	0·469530
" mean daily motion,	2·845712

2. *New Comet*, (Astron. Journ., 76.)—A new comet was discovered on the 13th of Sept. by Mr. Robert Van Arsdale at Newark, N. J. Its position, Sept. 3d, $9^h\ 50^m\ 30^s$ was R. A. $8^h\ 21^m\ 36^s$, and Decl. +74° 30′.

V. Miscellaneous Intelligence.

1. *Correspondence of M. Jerome Nicklès, dated Paris, Sept.* 2, 1854.

Death of Dr. Lallemand and of Melloni.—Science has experienced a great loss in the deaths of Dr. Lallemand and the Physicist Melloni. The former died at the age of 65 years, leaving a great void in medico-chirurgical science, of which he was one of the most illustrious representatives. Melloni died suddenly from an attack of cholera, when he was just giving his last stroke to a work on electrostatic induction. His death took place on the 7th of August, while he was living on a small farm where he had retired since the king of Naples had taken from him the direction of the Naples Observatory and deprived him of the means of making researches. His age was 56 years. We have not had time to collect together an account of the checkered life and labors of these eminent men, and will return to them again in our next communication.

Weights and Measures.—A Turk, M. Bilizidkdji, has called the attention of the Academy of Sciences to the many defects in the present system of weights and measures used in Turkey, representing the necessity of establishing there a uniform system cerresponding as nearly as possible with the metric of France. The weights and measures in Turkey vary not only from Province to Province and town to town, but also according to the different professions, and the nature of products. It is nearly as it was in France before the Revolution. On the Report of General Morin, the Academy expressed the desire that the Ottoman government, as soon as the war ceased or gave leisure for it, should take up the subject and establish a plan on the metric system.

We observe in this connection that two governments have recently adopted this system, the Republic of Mexico and that of New Grenada, and orders were given to M. Silbermann to supply the standards of the system, (a metre, kilogram and liter.) These units have been finished by the late Gambey; and before delivering them over they were compared with the fundamental standards by Silbermann in the manner explained in this Journal (January and May, 1853, and page 388 of the present volume,) and verified nearly to the hundredth of a milligram or a millimetre. There are now 17 of these units at the Conservatory of Arts and Trades; they are intended for those governments that order them, or that offer their own standards of weights and measures in exchange. A score of setts have already been distributed, to the United States, Spain, different states of Germany, and Italy. England and Austria are now the only nations of the first order that do not possess them. Prussia and Russia received them long since.

Researches on Colored Impressions produced by the Chemical action of Light.—It is more than six years since M. Edmond Becquerel succeeded in preparing a surface chemically impressible to light, such that it would take the color of the luminous rays which fell upon it. He has recently returned to the subject and perfected his methods; and he now describes with details his processes which enable him to realize a species of artificial retina which is of great sensitiveness, and is acted

upon only by the visible rays of the spectrum. These rays preserve their shade of color with only a slight modification; the orange rays, for which the luminous intensity is at its maximum, are the first to impress their image, but he has not succeeded in fixing them. The sensitive material used is a chlorid of silver containing less chlorine than the ordinary chlorid, and often found mixed with the latter.

The method most successful in preparing this sensitive chlorid, consists in decomposing rapidly by an electric current a solution of chlorhydric acid in water and causing the chlorine to come in contact with the plate of silver while the latter is placed in contact with the positive pole of a battery. As it is impossible to enter into the details of these important researches, we give only these general indications of his method.

Protection against Hail.—The second volume of the works of Arago have called attention to several points in Meteorology, among which is the subject of hail and the means of protecting fields from this evil. In the chapter which he devotes to this important subject he states that in 1847, two small agricultural districts of Bourgogne had lost by hail crops to the value of a million and a half francs. Certain of the proprietors from the neighborhood went to consult Arago on the means of protecting themselves from like disasters. Resting on the hypothesis of the electric origin of the hail, he suggested the discharge of the electricity of the clouds by balloons communicating by a metallic wire with the soil, as mentioned in a preceding number of this Journal (Jan. 1853, p. 111). These projects however were not carried out; and in view of the doubts as to the electric origin of hail, he proposed to investigate the subject anew. He had not the time to bring out any results; but he persisted in believing in the effectiveness of the method proposed.

Another subject is discussed in this volume. Arago enquires whether the firing of cannon can dissipate storms. He cites several cases in its favor and others which seem to oppose it; but he concludes by recommending it to his successors. Whilst Arago was propounding these questions, a man not conversant in Science, the poet Méry, was collecting facts supporting the view; and since the publication of the second volume of Arago's work, he has been led to give his results to the public. In a remarkable pamphlet entitled "Paris futur," he concludes strongly on the efficaciousness of the firing of cannon in dissipating storms, and mentions numerous observations in support of it. He says that his attention was called to the subject in 1828, while an assistant at the "Ecole de tir" of Vincennes. Having observed that there was never any rain on the morning of the exercise of firing, he was led to examine the annals of military and revolutionary science, and he found there, as he says, facts which justified the expressions which became common, such as "Le soleil d'Austerlitz," "Le soleil de Juillet" upon the morning of the revolution of July, and he concluded by proposing to construct around Paris 12 towers of great height which he calls "tours imbrifuges," (imbrifugal towers,) each carrying 100 cannons, which should be discharged into the air on the approach of a storm. Although this pamphlet was the offspring of a man of imagination instead of a scientific man, it has attracted attention, giving occasion to some

interesting discussion of which report says the *pro* and the *con* were sustained with equal success; this was at the commencement of the present month (August); to-day the subject is forgotten; and why has it deserved to pass so soon into oblivion? It was in consequence of a negative fact. The 14th of August was a fine day. On the 15th, the *fête* of the empire, the sun shone out, the cannon thundered all day long, fire-works and illuminations were blazing from 9 o'clock in the evening. Every thing conspired to verify the hypothesis of M. Méry, and chase away storms for a long time. But towards 11 in the evening a torrent of rain burst upon Paris in spite of the pretended influence of the discharge of cannon, and gave an occasion for the mobile Gallic mind to turn its attention in other directions.

Diseases of Plants.—Communications on the cholera, the disease of the vine, of the potato, and of plants in general, have multiplied rapidly in consequence of the prizes that have been offered. Memoirs from Germany continue to come in numbers; but they have not yet presented any fact worth mentioning. A first Report on this subject was recently made by the botanist M. Montagne, who has studied the various communications with care. None are satisfactory; the theories are vague and uncertain; the methods of prevention are in general ridiculous or impracticable; and the subject is still left for the future to solve.

This is not the opinion of the "Société d'Encouragement" who have more seriously verified the facts, and according to whom, important results have already accrued to agriculture. If we cannot yet avoid the disease of the vine altogether, we know at least how to cure it; this being the result of experiments made on a very great scale at Thomery in Bourgogne where the vineyards were much infected by the disease. Injections of sulphur skilfully made, have saved the crop, and enabled the Commune of Thomery alone to send to Paris in 1853 more than a million kilograms of the white grape, ("chasselas") of excellent quality. The sulphur was applied three times in the year; it is reduced to powder, and by the aid of a bellows of peculiar contrivance it is thrown upon the vine; the application of it is made in different directions in order that the sulphur may be brought in contact with the whole surface of the plant. The first application is made when the shoots are several centimeters long, the second after flowering, the third before the grape reaches maturity. The operation succeeds best in the sun, the time taken being always from noon to 2 P. M., and 20 to 23 kilograms of sulphur are employed per hectar. In hot-houses the method is more simple, as it is sufficient to spread the sulphur on the heating tubes, when the vapor rises and answers the purpose desired.

While admitting that much remains to be accomplished, the Society has done justice to several works treating of the vine disease; that most highly honored, is the treatise of a modest agriculturalist, *M. Gontier*, who suggested the use of sulphur, an idea which he put in practice, and for which he contrived a peculiar kind of bellows. The subject is up for a prize of 20,000 francs, next year.

Dimorphism.—In the number of this Journal for May, of the present year, at page 414, I have spoken of one of my papers having for its object the determination of the influence which the medium may

exert on crystals in process of formation. I showed that by varying a saline solution by means of a substance foreign to the definite compound, we may by this means vary the molecular forces which preside in crystallization and cause a change in the crystalline type of the substance, in case the substance is susceptible of becoming dimorphous. M. Pasteur, Professor of Chemistry at the Faculty of Sciences at Strasburg, has obtained remarkable results of this nature, with dimorphous substances presenting left and right (or non-superposable) hemihedral crystals; using the two hemihedral forms of one and the same compound, as the neutral tartrate of ammonia, spoken of in preceding numbers of this Journal. These two forms belong to the system of the right rhombic prism (trimetric), and differ only in their opposite hemihedrism. But M. Pasteur has obtained with each of these two forms a second form, wholly unrelated to the first, and crystallizing in the oblique rhomboidal system [monoclinic ?], which make in all four hemihedral forms not superposable obtained with one substance.

To obtain this result, it is only necessary to take a solution of one or the other variety of this trimetric tartrate, the right or left, and add a small quantity of neutral malate of ammonia; the malate does not appear to enter into the compound; it exerts an action of presence which changes the condition of equilibrium of the molecules. M. Pasteur calls this new kind of hemihedrism, tetartohedrism; and the forms, tetartohedral.

Coloring matter of Flowers.—This question has been studied by several chemists, and still it is beyond doubt, one of the most obscure subjects in vegetable chemistry. Botanists have long admitted that flowers owe their color to two coloring principles, a blue, called *cyanic*, and the other yellow called *xanthic*. For some time the blue color of blue flowers was attributed to the presence of indigo; but M. Chevreul showed that this blue is always reddened by acids, which fact set the indigo theory aside.

MM. Frémy and Cloez have isolated the blue principle and they call it *cyanine*. To obtain it, they treat with boiling alcohol the petals of the violet or iris, until the flower is colorless and the liquid takes a fine blue tint. This tint disappears soon, but reappears on evaporating the alcohol in the air; on pouring water into the product of this evaporation, a resinous substance separates; the coloring matter remains in solution, and may be precipitated by acetate of lead; the precipitate is green; it is washed with a large amount of water and treated with sulphuretted hydrogen which removes the lead and leaves the cyanine in solution. It is gently evaporated in a water-bath, absolute alcohol is added, and then the cyanine is precipitated in bluish flocks by ether.

This coloring matter is uncrystallizable; acids turn it red, alkalies green; it combines with lime, baryta, etc; sulphurous, phosphorous and other acids discolor it; it resumes its blue color through the presence of the oxygen of the air.

The *coloring* material of roses, peonies, some dahlias, &c., is a modification of cyanine; the vegetable juices have an acid reaction (which changes the blue cyanine to red), while the juices of blue flowers are neutral. In the presence of alkalies, the rose color becomes first blue and then green.

The *yellow coloring material* has no relation to cyannine. There are two different substances, one insoluble in water, *xanthine*, the other very soluble, *xantheine*; the former is analogous to the resins, and along with cyanine it produces in flowers an orange color, a scarlet, and a red. The xantheine combines easily with oxyds; alkalies change it to brown of a very rich color, and of considerable strength; but acids cause the brown color to disappear.

These are the three principal coloring ingredients of flowers. M. Filhol, Professor in the Faculty of Sciences at Toulouse, who has studied this subject, confirms in general the results of MM. Frémy and Cloez. He has however found that these coloring matters may be disguised or even destroyed by mixture with the juices of white flowers.

M. Pepin, "Chef des cultures" at the Jardin des Plantes of Paris, has made some curious observations, on the change of color which culture produces in flowers. He has found that cultivated annuals experience a change of tint more promptly than perennial plants, for each year they are renewed through the seeds. Such a change is however sometimes produced in biennials and perennials, and rarely ever in ligneous species.

The annual plants of Chili, Texas and California, have a strong tendency to produce varieties with white flowers, especially when their flowers present either of the primary colors, red, yellow or blue. The same is true of many other species introduced into France. Thus the *Clarkia pulchella* and *C. elegans* whose flowers have a violet tint, have produced white and rose-red flowers; the *Gilia*, blue and tri-colored; the *Leptosiphon* having red flowers, has produced pure white. The varieties with a white color are first produced, and afterwards the variegated.

Various Memoirs.—Among the more important papers read before the Academy of Sciences during the last two months, we must first notice, an important memoir by M. Daubrée, Professor of Mineralogy in the Faculty of Sciences of Strasburg, on *the Artificial Production of Minerals of the family of silicates and aluminates, by the reaction of vapors on rocks.* By the reaction of chlorid of silicium in the state of vapor, and at the temperature of red heat on the bases which enter into the constitution of rocks, he obtains by double decomposition and according to the nature of the base, *crystallized quartz*, *chrysolite*, *kyanite*, *idocrase*, *garnet*, *zircon*, *etc.* A memoir of MM. Malaguti and Durocher, on *the resistance of hydraulic lime and cements to the destructive action of seawater.* A memoir of M. Bechamp, Professor at the School of Pharmacy of Strasburg, on *the action which chlorid of iron exerts on different nitrated substances*, in continuation of a work mentioned in a former number of this Journal. *New observations on butylic alcohol*, by M. Wurtz,—the discovery of which is mentioned in the number of this Journal for Jan., 1853, p. 112. *New observations of caprilic alcohol*, by M. Bonis, a subject also alluded to in a former number. M. Deville communicates *new processes for preparing Aluminium*, and he accords in these processes with those which M. Bunsen has recently described in Poggendorff's Annalen. M. Melloni, just before his death, sent in the first part of his *Researches on Electro-static induction;* and M. Abria, Professor in the Faculty of Sciences at Bor-

deaux, has presented some *Researches on the laws of the magnetism of rotation.* It is impossible to give here details of these memoirs, which moreover will all appear in the official organ of the Academy of Sciences, the Comptes Rendus, published every Saturday.

Manufacture of Powder.—In the No. of this Journal for Sept. 1853, p. 270, I have spoken of an improvement in the manufacture of powder, applied for the first time at the manufactory of Esquerdes which produces, owing to this improvement, the products highest in reputation in France or other countries. The improvement depends on a new method of preparing the charcoal, which is obtained by calcination of the wood by means of a current of overheated steam. This charcoal, called *charbon roux*, has but one objection, which is its price.

To overcome this difficulty, another member of the commission on powder and saltpetre, M. Gossart, has devised a method of executing this process, by heating with gas, which saves about 80 per cent. of the cost of the process for heating the steam.

It is apparent that this method is not only applicable to steam and to carbonisation, but may be employed with advantage whenever a fluid is to be heated. But the author has had in view specially the making of red charcoal (charbon roux), and on this point it has been examined by the committee of the Artillery. The following is an extract of the report by this committee to the Minister of War.—"With the apparatus proposed, 100 kilograms of wood may be carbonised at once. The following is the method.—The water for evaporation is injected through a pump whose piston is charged with a weight little above the force of tension desired for the vapor. The pressure causes the water to rise through a graduated orifice, in a series of tubes arranged like a ladder, and enclosed in tubes of larger bore. These last convey the gas, and also serve for the condensation of the steam after it leaves the carbonising apparatus. The circulation goes on from above downward. By this arrangement, the cold water of the tubes will absorb the greatest part of the heat of the gas and of the condensed water, thus heating itself more and more in its upward movement; it finally reaches the temperature of ebullition and is in part turned into steam in a serpentine with parallel tubes arranged so as to cover the top and sides of the furnace. The water vaporises in these tubes and is overheated in its passage across the metal turnings or granulated metal with which they are filled. The steam thus overheated is conducted into a reservoir of cast iron furnished with a thermometer and a manometer indicating its heat and tension; then it passes to the carbonising apparatus. To pass out of this apparatus, the steam and gas are conducted in the enveloping tubes mentioned above; the condensed water and the gas, now nearly cold, pass out to be rejected by an arrangement for this purpose at the lower part of the apparatus. The air for promoting the combustion is heated by passing along a portion of the walls of the chimney and the vent-holes before arriving under the grating, by which means, heat is economised. The following are the advantages of the method.

1. Only one fire is used for producing the overheated steam; and a single fireman suffices.

2. Only the amount of water actually necessary for producing the steam is heated, and just as it is required.

3. The greater part of the heat is utilised, which was before carried off by the steam and gas and totally lost.

4. The use of metallic furnaces renders it easy to multiply the heating surfaces, and at little cost.

5. The heating is regular, the temperature very equal, and the products obtained are uniform.

6. The best heating effects are secured by the arrangement for bringing the hot air under the grating."

The committee hence recommend an appropriation to enable the powder establishment of Esquerdes to make these arrangements. The appropriations have been authorized. We propose hereafter to speak of the fabrication of sugar and of distilling by this method.

Stereoscopy.—The invention of the refractive stereoscope has quite generally been attributed to Sir David Brewster, especially in France. A recent writer has corrected the error. The Abbé Moigno, in giving an account of a visit to England, in his Journal, Le Cosmos, observes that he saw in the hands of Mr. Wheatstone a letter written by Brewster, dated September 27, 1838, containing besides other things, the sentence, "I have also stated [to Lord Rosse] that you promised to order for me your stereoscope, both with reflectors and prisms." The stereoscope by refraction, says M. Moigno, as well as that by reflection, is Wheatstone's. The refracting stereoscope invented by Sir David, is a form in which the two prisms are the halves of a lens.

Photography—Painting transparent photographic images.—The coloring of photographic portraits has often been attempted; but the photograph is obliterated in the process, and after all only an ordinary painting is obtained.

M. Minotto, and also MM. Soulier and Clouzard, have succeeded in this art, by applying the color under the image. This method of coloring was used in 1824 at Strasburg, with lithographs, under the name of "oleocaleographie" and "lithrochromie." But it is especially applicable to photographs on glass, paper, tissue, and generally all transparent substances.

Photographs of monuments in Judea.—The state of art among the Jews has usually been lightly spoken of, and archeologists will not admit that they were artists. When M. de Saulcy, a French archæologist, returned from Palestine with a portfolio of crayon sketches representing the monuments of the Jews, his sketches were treated with a smile of incredulity. A photographer, M. Saltzmann of Colmar, has recently confounded the sceptic by taking the sun as his collaborator. His plates confirm the designs of M. Saulcy. They consist of 200 photographs, 50 of Jewish subjects, the rest of Roman, Byzantine, Latin, Arabic and Turkish monuments in Jerusalem.

New Collodion.—In the body of a silk worm just about to make its cocoon is found an organ full of the material which is to become silk. M. Legray has extracted from it a substance equal to albumen and collodion for photographic proofs. He proceeds thus:—He puts in a porcelain capsule the organs in question taken from 50 worms: 200 grams of distilled water are poured on it, containing 4 p. c. of carbonate of soda; the capsule is then heated, while agitating with a glass rod; after 10 to 20 minutes of ebullition, the small bags empty

themselves; they are then transferred to a piece of fine linen and pressed. The liquid is collected on glass and left to evaporate, when a pellicle forms like that of collodion. It should be used within 24 hours, as it afterwards becomes spongy and insoluble in water, alcohol and ether.

Impression by heat, or Thermotypy.—This process proposed by M. Abate is very simple, and is based on the destructive action exerted by chlorhydric acid on organic substances. Suppose for example we have a slice of wood of which we wish a faithful impression. The wood is exposed for some minutes, to the action of cold vapors of chlorhydric or sulphuric acid, or it is wet lightly with either of these acids diluted. The slice of wood, wiped with care, is placed on a piece of paper, cotton cloth, or white wood, in a press, and a blow struck. The impression is at first invisible; but on exposing it to a strong heat, it gradually appears, and exhibits a perfect picture of the wood. This operation may be repeated indefinitely. For oak, maple, hazel, &c., the picture is of the color of the wood; but for mahogany, rose wood and many others, the color is modified, and if a perfect colored picture is desired, it should be taken on a previously prepared tint of the required kind.

It occurs to us that, by taking an impression on a plate of zinc, tin, marble or other substance attacked by acids, a negative relief might be obtained, which would serve for reproducing pictures of the impressions. Finally, if the image of M. Abate is obtained with a substance which is a conductor of electricity, it may then be reproduced by electrotypy.

Electric illumination.—There have been recently some attempts made at Paris towards illuminating the bottom beneath water. At the lake d'Enghien, M. Duboscq, the successor of Soleil, performed an experiment of this kind before many competent observers. The electrodes of carbon were placed in a glass globe, being connected with one of Duboscq's regulators, which communicated with the battery by a copper wire covered with gutta percha. The globe submerged to a depth of 5 meters, spread light over a circumference of about 10 meters radius, and it remained constant for two hours, after which the carbon required replacing.

The idea of this process was suggested to Duboscq by an agent of the Company engaged in exploring the bottom of the Mediterranean where the battle of Navarino took place. The diver usually remained beneath the water three quarters of an hour, after which he came up to breathe and rest; his light was an oil lamp, placed on the head of the diver, and fed with air proceeding from his respiration, whence, it was in a variable current and was often extinguished, requiring him to go up and relight. Duboscq's arrangement was devised to avoid these inconveniences. It is light so that the diver may carry it in his hand, and at the same time it is strong and well secured hermetically, to resist a pressure of 50 to 60 meters of seawater. It consists of a cylinder of strong glass secured to a brass foot, and surrounded with a gutta percha sac. The light passes out through a large plano-convex lens, the convexity inward, the focus being so arranged that the rays escape nearly parallel. As the lamp is moveable, the diver walks about with it and places it where he wishes to make any search; and as it is only

necessary to bring the electrodes near one another to light it, the diver need only turn a small screw to continue the light for two hours, which is more than twice as long as he can remain at the bottom.

To illumine the bottom at small depths, Deleuil uses a Fresnel lens, and this is daily in operation in a bathing establishment—the baths of Henry IV, constructed on the Seine in the heart of Paris. The regulator and also the light are 10 meters above the surface of the water, and the light penetrates sufficiently far to enable us to see the swimmer at a depth of 2 to 3 meters, and follow all his movements.

2. *Notice of the "Fountain of Blood" in Honduras.*—The following letter from E. G. SQUIER addressed to B. SILLIMAN, Jr., refers to a remarkable phenomenon in Central America, the details of which are sufficiently given in the letter of Mr. Squier. The bottle of colored liquid which was placed by this gentleman in our hands has suffered the same fate as its predecessors, and its contents were so far changed by decomposition as to preclude all attempts at an accurate examination. The color of the fluid was dark brown, exhaling an offensive odor, and having a sediment somewhat copious in which the microscope detected no distinct forms of organization, although filaments of organic matter were abundant. The most probable conjecture as to the origin of this fluid, appears to be that which refers its color to the presence of some highly colored species of infusoria. A microscopic examination on the spot or a portion of the material in alcohol would easily settle the question. Meanwhile the following facts will be read with interest.

"*My Dear Sir*:—I send you herewith a bottle of a remarkable liquid obtained from what is called "*Mina ó Fuente de Sangre*," Mine or Fountain of Blood, in Central America. The locality is a small cavern, near the little town of Virtud, Department of Gracias, State of Honduras, on the western or Pacific slope of the Cordilleras. It has long been known, not only in its immediate vicinity, but in connection with various superstitious hypotheses, throughout all Central America. Mention is made of it in publications, dating back more than a hundred years. The following extracts from the '*Gaceta de Honduras*,' of the 20th of February, 1853 will serve to give the essential facts concerning it, so far as they are known:

'*Fuente de Sangre*.—A little to the south of the town of Virtud, Department of Gracias, is a small cavern (*gruta*) which is visited during the day by buzzards and *gabilanes*, and at night by a vast number of large bats (*vampires*), for the purpose of feeding on a kind of liquid which exudes from the rocks, and which has the color, smell, and taste of blood. A rivulet flows near this grot, which is constantly reddened by a small flow of the liquid. A person approaching the grot observes a disagreeable odor, and when it is reached, he sees several pools of the blood, in a state of coagulation. Dogs eat it eagerly. The late Don Rafael Osejo undertook to send some bottles of this liquid to London for analysis, but it corrupted within twenty-four hours, bursting the bottles.'

At my request Don Victoriano Castillanos, a gentleman of an observing turn living not many leagues from Virtud, sent me two bottles of this liquid, largely diluted with water, to avoid the catastrophe which happened to Gr. Osejo, and to all others who had attempted to carry

any portion of the supposed blood out of the country. One of these bottles, as I have already said, I send to you for examination, believing that the results may not be uninteresting to the readers of the Journal. New York, May 1, 1854."

3. *Nature doing her own engraving.*—In the fifth volume of the Denkschriften of the Royal Academy of Sciences at Vienna (Mathematico-Natural History Class), there is a paper by Alois Auer, and numerous plates, illustrating a new style of engraving. The plates represent leaves, plants from a herbarium, lace and other objects, and in each case, the object appears to be *on the paper*, the surface being raised and the coloring perfect. The deception is so complete that without a magnifying glass it is almost impossible in one or two instances to be sure that the object itself is not there. The process employed is the following: The pressed plant, or other object, is placed between a plate of copper and one of lead and subjected to pressure; the original thus produces a strong impression on the lead plate. By inserting the requisite colors with a point, in the depressions, a figure colored to nature, with different colors in its different parts, may be obtained at a single printing. From the lead plate copies may be taken by stereotype or galvanism, and copper plates are thus obtained more durable than those of lead. Gutta percha may be used in place of the lead, and by covering it with a deposit from a silver solution, the impression may be used for stereotyping or electrotyping.

4. *Mount Ararat and places in the Caspian Basin.*—Mount Ararat was ascended by Col. Chodzko of Russia in 1850. He found the height to be 15,912 French feet; and for Little Ararat 3852 feet less in elevation. M. Fedoroff found in 1829, 16,069 for the former and 12,232 for the latter. Parrot obtained 16,251 and 12,271 feet.

Lake Goktchaï near Erivan is not less than 5,510 feet (French) above the sea; and on its borders to the south and southeast there are ancient volcanoes 8000, 10,000 and 11,000 feet in height.

The height of the city of Teheran above the sea is 3579 French feet; of Meched 2865; that of the high mountain Schemrunn 12,247 feet; the famous peak of Demavend 18,846 feet, (which Frazer had made 10,000 feet, T. Thomson 14,000, Texier 4548 meters, and Humboldt in his *Central Asia*, vol. iii, 3066 toises.

The *lake Aral* derived its name from the string of islands on the east and north sides, the word in the Kirghis dialect meaning island. The lake is 50 leagues (French) broad and 100 long and about 109 times the surface of the lake of Geneva. The waters have the saltness of Finland, 25 leagues west of Cronstadt. The greatest depth, about 37 toises, is on the west side. It does not contain seals or crabs like the Caspian, nor various large species of fish which occur in that sea.—*Bib. Univ. de Genève, June*, 1854.

5. *Zodiacal Light.*—By letters from Rev. George Jones, U.S.N., now of the Japan Expedition, we learn that he has made numerous observations on the zodiacal light, leading to important conclusions. He remarks that "the light never fails to be seen when the moon or clouds do not interfere," a statement which accords with the observations of the writer. His results will be published on the return of the Expedition.—J. D. D.

6. *Notes on California;* by W. P. BLAKE, (from a letter to one of the Editors.)—I found a greater number of intruded igneous rocks in the Gold region than I anticipated. They vary in character and are probably of different ages. The prevailing trend is N. to N. 45° W., and when traversing slates they are generally comformable to the bedding. Quartz veins bearing gold are usually found connected with these intrusions and either traverse their mass or constitute a wall between them and the adjoining slates. Quartz veins traversing the slates *conformably* and *obliquely* without any apparent connection with the igneous intrusions are also common.

Some of the auriferous quartz veins are worked with great profit. Of this, I am satisfied from careful examination, and I have many interesting details on this subject.

The elevated placer deposits are very extensive, and are worked with much skill and success.

The numerous exploring shafts sunk in all parts of the country on the tops of the hills, have developed many interesting facts concerning auriferous drift. There is in most places where placer mining is being conducted above the present rivers, a thickness of two hundred feet or more of stratified materials that appear to have been laid in comparatively quiet water. The peculiarities of these deposits are so various and they are so different from those generally known as drift, that a wide field is opened for investigation and many detailed observations will be required, before we can understand the changes that have taken place in this part of the continent during and since the "drift period."

Since I wrote you about the gold and platinum from Port Orford, I have examined several other samples and find that the percentage of platinum is variable, and that iridosmine is generally in large proportion. I have now several ounces of the mixed metals separated from the gold. The grains are very hard but are probably too small to be used in the manufacture of pens.

7. *Homœography.*—A new method of copying pages of a printed work by transfer, invented by M. Edward Boyer in France, is thus named. It is claimed that any book or engraving may be thus copied with little expense, and copies multiplied indefinitely, so that a book, however rare, never need be out of print. It is done rapidly, without injuring the original, and so exactly that the most practised eye cannot tell the difference.

8. *Sketch of the Life and Labors of Dr. Thomas Thomson,* F.R.S., &c., Prof. Chem. Univ. Glasgow, etc., delivered at the opening meeting of the Glasgow Philosophical Society of Nov. 5, 1852, by WALTER CRUM, F.R.S., Vice-President of the Society.—Dr. Thomson died on the 2d of July, 1852, at 80 years of age, after long service in the cause of science. Mr. Crum gives the following facts showing the part Dr. Thomson took in the promulgation of the Atomic Theory.

"On the 26th of August, 1804, Dr. Thomson went to Manchester, and saw for a day or two much of Mr. Dalton, who explained to him his views on the composition of bodies. He saw at a glance, as he tells us, the immense importance of such a theory, and was delighted with the new light which immediately struck his mind. He wrote down at the time the opinions which were offered, and three years later, when

about to publish the third edition of his System of Chemistry, he obtained Dalton's permission to insert the sketch he had taken, before Dalton himself had given it to the world. The theory was at that time very slenderly supported by facts, for chemists possessed few experiments which could be considered as even approaching to accuracy. Up to this time when Thomson published the sketch, he seems to have been Dalton's only convert. Perhaps no other chemist had taken the trouble to listen to it, if we except Dr. Henry of Manchester, who was Dalton's frequent visitor, but there is no probability that even he at so early a period accepted the theory, for he speaks of it, so late as 1810, in rather doubtful terms, in the sixth edition of his "Elements."

Thomson's paper on the oxalates, read to the Royal Society in 1807, contained the first direct example of the application of the Daltonian theory to supersalts. He there shows that oxalic acid unites with strontian as well as with potash in two different proportions, and that the quantity of acid combined with each of these bases in their superoxalates, is just double of that which saturates the same quantity of base in their neutral compounds. During the same year Dr. Wollaston read his famous paper on the oxalate, binoxalate, and quadroxalate of potash, and he commences it with a relation of what Thomson had already done. He states that he had remarked the same law to prevail in various other instances of superacid and subacid salts, and that he had intended to pursue the subject so as to learn the cause of so regular a relation; but that such a pursuit was rendered superfluous by the appearance of Dalton's theory, as explained and illustrated by Thomson. He shows also that the bicarbonate of soda loses one-half its carbonic acid by exposure to a red heat—that the potash in supersulphate of potash is united to twice as much acid as the same quantity of potash in the neutral sulphate, and that potash unites with three different quantities of oxalic acid, which bear to each other the relation of 1, 2, and 4. Dr. Thomson always said, that in the absence of Dalton, Wollaston would have been, very soon, the discoverer of the atomic theory.

These facts gradually drew the attention of chemists to Mr. Dalton's views. Sir Humphry Davy, however, and others of our most eminent chemists, were hostile to them. In the autumn of 1807, Dr. Thomson had a long conversation with Mr. Davy at the Royal Institution, during which he attempted in vain to convince him that there was any truth in the new hypothesis. A few days after, he dined with him at the Royal Society Club at the Crown and Anchor in the Strand. Dr. Wollaston was also present. After dinner every member left the tavern, except Dr. Wollaston, Mr. Davy, and himself, who all remained behind, and sat an hour and a-half conversing upon the atomic theory. Wollaston and Thomson tried to convince Davy of the inaccuracy of his opinions; but he went away more prejudiced than ever. Soon after, Davy met Mr. Davies Gilbert, the President of the Royal Society, and exhibited to him the atomic theory in so ridiculous a light, as to make Mr. Gilbert call afterwards on Dr. Wollaston, to learn, probably, what could have induced a man of his sagacity and caution to adopt such opinions. Dr. Wollaston begged of Mr. Gilbert to sit down and listen to a few facts which he would state to him. He then went over the principal facts, at the time known, respecting the salts in which the proportion of one

of the constituents increases in a regular ratio; and the relations also which Dalton had found carbon to bear to hydrogen in olefiant gas and carburetted hydrogen. Mr. Gilbert went away a convert to the truth of the atomic theory, and had soon the merit of convincing Sir Humphry Davy, who ever after was a strenuous supporter of it.

Instead of Dalton's term "atom," which Thomson adopted, Davy always used the word "proportion," and Wollaston "equivalent," which was much better; but whatever term we employ, now that the thing itself is understood, there can be no doubt that the use of the word "atom," (which conveys at once the idea of an ultimate indivisible particle,) greatly contributed to the reception of the doctrine of definite proportions. In 1808 Mr. Dalton published a volume of his own, in which not more than five pages, widely printed, and one plate with explanations, were devoted to the announcement and illustration of the atomic theory. This treatise, if such it can be called, is little more copious than that which had been given the year before from Dr. Thomson's notes."

9. *Prefatory Notice of Laurent's Méthode de Chemie;* by J. B. Biot.—This work, rich in new ideas, which have often proved fruitful to the author himself, offers us the deep convictions of a man who has enriched science with numerous and unexpected discoveries. It is the review of the thoughts of his life; and he felt so deep an interest in leaving behind him this bequest, that he labored to complete it even while in the arms of death. These reasons demand that the work should be received with serious consideration, and a mind free from previous prejudices. But to read it with profit and a just appreciation, it is important to bear in mind the *end* which Laurent had in view in its composition. He desired to place in the hands of chemists a collection of analogies drawn from experiment, which should guide them by the strongest probability if not with entire certainty, in the explanations to which they are continually obliged to have recourse. The operations of chemical analysis, whether applied to native or to artificial products, make known only the nature and relative proportions of the elements which compose them. They cannot teach us whether the molecules of the constituent elements are combined in all cases according to a single general mode alike for all; or whether they are distributed into distinct groups, combined among themselves without individual decomposition, and coexisting with their peculiar properties in the complete product. This question it is all important to decide, and to ascertain the special conditions in either case. For we should expect that the reactions of a substance would differ according as its molecular constitution is homogeneous or heterogeneous; and in the latter case according to the nature of the groups therein associated. Thus there are abundant examples of bodies, formed from the same simple elements and in the same proportions of weight, which are wholly diverse in chemical and physical properties. On this point, the most elevated in chemical reasoning, analysis gives no direct information, since its results only distinguish the simple elements separated from each compound, and affirm nothing as to whether they are isolated, or combined in groups whose preëxistence cannot be affirmed. Hence it may be justly said that it judges of bodies only after they have ceased to exist.

The preëxisting state of such bodies can therefore be determined only by induction, and must rest upon the analogies of properties and reactions; or else upon theoretical views which by giving a simple conception for each body under consideration connects it by probable marks with those substances with which it appears to have the closest relations in molecular constitution.

Now this latitude which each chemist allows to himself in each particular series of his investigations, has introduced great confusion into the science which must still increase; particularly in proportion as we advance in the study of organic products, where the combinations of a small number of simple substances, always the same, present a diversity almost infinite. Laurent has had in view to control the exercise of this liberty by subjecting it to general and uniform laws. Among the great number of formulas by which the bodies made known by chemical analysis can be theoretically represented, he proposed to seek out those which in the present state of our knowledge should be preferred, as offering the most general advantages for classification and the practical study of compounds; and by bringing together analogous species and separating those which are unlike by characters both numerous and striking, to enable one to foresee, from a careful inspection of the symbolic formulæ, the greatest possible number of reactions which they may exert and the products which may be thereby deduced from them. In a word, he has attempted by a comprehensive method, to do that for the collected researches of the chemical science of the day, which each chemist is trying to do in his own line of research, with limited and arbitrary views. Has he succeeded in this great task, for which perhaps chemical science hardly offers sufficient material in the way of well ascertained facts? This no one will be bold enough to affirm, nor unjust enough to demand. The inquiry we should make in reading his work is, whether, in the majority of cases on which he has relied to sustain himself, his views are conformable to experience; so that each may have a chance of finding them fruitful in his own case, as they have been to Laurent and others. If they have this effect, even within these limits, he will not fail to applaud, while laboring to carry the principles to perfection. To repel or reject them at first view because they are strange or perhaps announced with too great boldness of expression, would be a policy little likely to advance science. If our author sometimes attacks rather rudely the edifice of chemical science which has been formed by slow and successive additions, it is because, seeing the incoherence of the accumulated materials composing it, he has believed it to be more profitable to labor for its reconstruction, than strive to preserve it as it is. He has aimed only to assist in the undertaking, by pointing out the relations of types and symbols, which, in the absence of more accurate notions, offer generally some reliable grounds for grouping or separating species. In a majority of cases, chemistry will thus be able to escape from that empiricism in which until lately it has remained.

The power of rotating polarized light exercised by a great number of bodies, as far as known exclusively organic, furnishes a definite character by which the abstract speculations based upon the constitution of the compounds of which they form a part may be either confirmed

or set aside. The application of this character, thus directed, offers a direct and sure method, for resolving a multitude of controverted questions in rational chemistry, of the kind which Laurent has treated. But the employment of this method is as yet but little extended, although it has always been fruitful for those who have employed it in their researches.

10. *Smithsonian Contributions to Knowledge.* Vol. VI. 1854.—In the volumes of able papers which are issued under the Smithsonian fund, this Institution is conferring a lasting benefit on the cause of knowledge through the land and through the civilized world. Works, the result of profound research, which would fail of a publisher because not fitted to command a ready "cash" return, here find encouragement and the means of an honorable introduction to the libraries of the land, and directly or indirectly, the views, new principles, and results of researches and explorations over this and other lands, gradually pass into general circulation. The volume just now issued, the sixth of the series, contains the following memoirs:—

Plantæ Fremontianæ, or Descriptions of Plants, collected by Col. J. C. Fremont in California; by JOHN TORREY. 24 pp. and ten plates.

Observations on the Batis maritima of Linnæus, by JOHN TORREY. 8 pp. and one plate.

On the Darlingtonia Californica, a new Pitcher Plant, from Northern California; by JOHN TORREY. 8 pp. and one plate.

Synopsis of the Marine Invertebrata of Grand Manan, or the Region around the Bay of Fundy, New Brunswick; by WM. STIMPSON. 68 pp. and three plates.

On the Winds of the Northern Hemisphere; by JAMES H. COFFIN, Prof. of Mathematics and Natural Philosophy in Lafayette College, Pa. 200 pp. and 13 plates.

The Ancient Fauna of Nebraska, or a Description of Remains of Extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska; by JOSEPH LEIDY, M.D., Prof. Anat. Univ. of Pennsylvania. 124 pp. and 25 plates.

Appendix: Occultations of Planets and Stars by the Moon, during the year 1853, computed by JOHN DOWNES.

The long paper by Prof. COFFIN consists largely of tables, presenting abstracts of observations, bearing on the winds and temperature of the different zones and regions of the globe. It embodies also deductions from the observations, which are of great interest, although of course liable to modifications in some cases, as facts are further multiplied. The following are some of these conclusions:

(1.) In the Arctic regions of North America, within the Polar circle, the mean direction of the wind is about *north-northwest*, and well defined.

(2.) Between the parallels of latitude—60° and 66° there appears to be a belt of easterly or northeasterly winds.

(3.) South of this belt, there is a zone of westerly winds, (as now commonly recognised) which encircles the globe, and is about 23½° in breadth. Near the limits which divide this zone from the Polar winds on the north and from the equatorial on the south (particularly the latter)

the progressive motion is very small. The progressive motion moreover is less in Europe than in America.

(4.) South of this zone and contiguous to it, the winds in the United States and on the Atlantic are on the whole easterly, though quite irregular, with small progressive motion.

(5.) Further south, there are the well known northeasterly trade winds, stronger between 10° and 25° than nearer the equator. In the eastern Atlantic near Africa, the winds incline towards the great Desert. In southwestern Asia, they are very irregular, and defy all attempts to reduce them to system.

The system of winds of the northern hemisphere are therefore regarded by the author, as (1) a southerly in direction in the high northern latitudes, but veering towards the west as they approach a limit ranging from about latitude 56° on the western continent to about latitude 68° on the eastern, when they become irregular and disappear; the area of this zone is about 11,800,000 miles; (2) a zone of westerly winds around the earth less than 2000 miles broad; area about 25,870,000 square miles; (3) south of this last zone, a zone of easterly winds—area about 60,760,000 square miles.

(6.) On each side of the Atlantic there is a system of winds possessing monsoon features. Drawing curved lines to represent the mean annual and the monthly tracks, the curves for the warmer months, fall inside of the mean in the warmer months and outside in the winter, showing a deflection towards the land in the former and towards the sea in the latter—an effect which the author alleges to be "most convincing proof of the influence of heat in the production of winds and that too upon an extensive scale." These monsoon winds are stated to be analogous to land and sea breezes, only on a grander scale. The influence of the northern lakes on the direction of the wind, and also of deserts, is discussed in this connection.

These are some of the points brought out in Professor COFFIN's paper.

The extended paper on the Nebraska fossil Mammalia by Prof. LEIDY, contains elaborate descriptions and illustrations of the ancient Fauna of the remarkable Mauvaises Terres, an earlier less complete paper on which by the same author has already been noticed in a former number of this Journal. The Mammalia all belong to the order Ungulata or hoofed Mammalia, excepting a single carnivorous animal of the feline genus Machairodus. Of Chelonian Fossils, there are five species all of the genus Testudo. The following are the names of the Ungulata described.

Poebrotherium Wilsonii, Leidy—most nearly allied to the musks.

Agriochœrus antiquus, Leidy.—In structure between the ordinary Ruminants and the anomalous Anoplotherium.

Oreodon, Leidy.—Also between ordinary Ruminants and the Anoplotherium. Species Oreodon Culbertsonii, about the size of the wolf of Pennsylvania; *O. major*, larger than the Culbertsonii.

Eucrotaphus, Leidy.—Probably related most nearly to Oreodon. Species, *E. Jacksoni* and *E. auritus*.

Archæotherium, Leidy.—A genus of Suilline Ungulates.

Species, *A. Mortoni*.—Head about as large as that of the Lion. *A. robustum*, still larger.

Anchitherium, Meyer.—Related to Palæotherium.

Species *Anchitherium Bairdii*.

Titanotherium, Leidy.—Related to Palæotherium. Species *T. Proutii*, (this Journal, 1847, iii, 248.)

Palæotherium giganteum, Leidy.—Twice the size of the P. magnum.

Rhinoceros occidentalis, Leidy.—Three-fourths as large as the R. indicus. *R. Nebrascencis*, one-fourth smaller than the R. occidentalis.

The species of Carnivora described is the *Machairodus primævus*, an animal a little smaller than the American Panther.

The plates illustrating this paper are admirable. The Mauvaises Terres or Bad Lands, are situated near latitude 42° N. and longitude 26° west from Washington, or 103° west from Greenwich.

11. *Verd Antique Marble*.—The papers state that the new City Hall of New York is to be built of Verd Antique or Serpentine marble, either from Vermont or the quarries of Milford, Connecticut. The latter is a miserable material for all out-door use, though elegant for in-door purposes. When the Milford quarries were first opened some 35 to 40 years since, the polished slabs were used as monuments in the New Haven Cemetery; and now they are as gray and rough as if remnants of Assyrian antiquity. The Vermont material is more purely a serpentine rock, and will not wear as unevenly. But unpolished, it is a dull, blackish, gloomy stone, turning brownish gray on exposure, and fit only for a prison. It is quite time that in the selection of building material for public structures in the United States, some reference should be had to the quality and fitness of the rock. The Greeks were wise in using material which 2000 years have not wasted nor diminished in beauty.

12. *Mastodon*.—A skeleton of a Mastodon has been recently discovered buried in a marsh about two miles from Poughkeepsie, New-York. Its state of perfection is not known, as it is yet but partly exhumed. This is the second skeleton obtained from the vicinity of this city.

13. *British Association*.—The British Association commenced its session for the present year at Liverpool, on the 20th of September last.

14. *Ueber das Iridium und seine Verbindungen*. Inaugural-Dissertation zur Erlangung der Philosophischen Doctorwürde von Ezequiel Uricoechea, aus Bogota. 38 pp. 8vo. Göttingen, 1854.—The author of this Inaugural Dissertation, Mr. Uricoechea, from Bogota, has just graduated with honors at the Göttingen University, in the Department of Philosophy. A history of the discovery of the Platinum metals is first given, in the course of which he observes that, the word Platina, although derived from the Spanish *Plata*, silver, is not properly a diminutive of that word, but signifies more correctly *silver-like*, or like silver. He cites the sentence from Scaliger, of the 16th century, in which he alludes to this metal, as follows: "Præterea scito, in funduribus qui tractatus est inter Mexicum et Dariem, fodinas esse orichalci quod nullo igni, nullis Hispanibus artibus, hactenus liquescere potuit;" and also, the subsequent notice of it in the Relacion historica, &c. of Ulloa, "Donde la Platina (piedra de tanta resistencia que no es fácil

romperla ni desmenuzarla con la fuerza del golpe sobre el Yunque de acero) es causa de que se abandonen; porque ni la calcinacion la vence; ni el arbitrio para extraer el metal que encierra, sino á expensas de mucho trabajo i costo." The author ably reviews also the scientific history of the platinum metals, and especially of Iridium, and closes with some results of his own investigations on the Phosphate of oxyd of Iridium, Bromid of Iridium and Sodium, Bromid of Iridium, Sulphates of oxyd of Iridium and Chlorid of Iridium and Magnesium.

15. *The Chemistry of Common Life;* by JAMES F. A. JOHNSTON, M.A., F.R.S., F.G.S., &c. 12mo. New York, 1854. D. Appleton & Co. Nos. I, II, and III.—The subjects treated of in these three Nos. are "The Air we Breathe," "The Water we Drink," "The Soil we Cultivate," "The Plants we Rear," "The Bread we Eat," "The Beef we Cook," "The Beverages we Infuse," "The Sweets we Extract," "The Liquors we Ferment," and first part of "The Narcotics we Indulge in." In all 270 pages 12mo.—Science is here brought to bear successfully and attractively on the common processes of domestic and out-door life. The three numbers issued are about half the whole work.

16. *Scenery, Science and Art, being Extracts from the Notebook of a Geologist and Mining Engineer;* by Professor D. T. ANSTED, M.A., F.R.S., &c. 324 pp. 8vo. London, 1854. J. Van. Voorst.—Prof. Ansted's work contains brief but animated descriptions of the people and country met with in his travels, ranging through portions of France, Switzerland, Germany, Spain, Sardinia, Algiers, and the United States; and many excellent views, part in lithotints, illustrate the scenes of which it treats. A large part of the volume is devoted to the mines, mining resources and geology of the regions visited, and these add largely to the substantial value of the work.

17. *Souvenirs d'un Naturaliste;* par A. DE QUATREFAGES, Membre de l'Institut. In 2 vols. 18mo. Paris, 1854. Victor Masson.—The author of this work, A. De Quatrefages, is one of the most active and thorough Zoologists of France. These volumes are in part a popular Journal of his various excursions to the Mediterranean and other regions, and partly reflections and discussions on scientific topics, of more or less general interest. His object, as he states, in his Preface, was to present the great truths and principles of zoology in a manner that should make their true bearing, interest and value apparent to the public at large. Whether speaking of the incidents of his tours, the people among whom he is cast, or of science, the work is interesting and instructive.

18. *The Principal Forms of the Skeleton, and of the Teeth;* by Professor R. OWEN, F.R.S., &c. 330 pp. 12mo. Philadelphia, 1854. Blanchard & Lea. This book is by the most eminent Comparative Anatomist of Britain. It was written as an introduction to his favorite Science, and reviews the structure of the principal forms of the Skeleton, and of the Teeth in the Vertebrata. It is illustrated by many wood-cuts.

19. *Principles of Comparative Physiology;* by WM. B. CARPENTER, M.D., F.R.S., &c. 752 pp. 8vo, with 390 wood-cuts. A new American, from the 4th and revised London edition. Philadelphia, 1854. Blanchard & Lea. The whole range of organic nature, both vegetable

and animal, is treated of in a physiological point of view, in this elaborate work of Dr. Carpenter: and there is no Treatise in the English language, that covers the same ground in so able a manner.

20. *Human Physiology*, designed for Colleges and the higher Classes in Schools, and for general reading; by WORTHINGTON HOOKER, M.D. 390 pp. 12mo, with nearly 200 wood-cuts. New York, 1854. Farmer, Brace & Co.—Dr. Hooker writes with perspicuity, explains difficult points with simplicity, and adapts his subject well to school instruction and general reading. His work treats first, of the general distinctions of organized and unorganized substances, the distinctions of animals and plants, and man's relations to the three kingdoms of nature; second, of the Human Structure as bearing on Physiology; and third, the uses for which the structure is designed.

21. *Science and Mechanism Illustrated by Examples in the New-York Exhibition*, 1853–54; including extended descriptions of the most important contributions in the various departments, with annotations and notes relative to the Progress and present state of applied Science and the useful Arts. Edited by E. R. GOODRICH, Esq., aided by Professors HALL and SILLIMAN, and other scientific and practical men. New York, G. P. Putnam & Co. 1854. 4to, pp. 258, with numerous illustrations.

This long expected volume has at last appeared and is published in a uniform style with the Illustrated Record, of last year. It embraces a vast variety of information, much of it novel and curious, upon the wide range of topics covered by its 31 Classes. The parts devoted to Mineralogy, Geology and Mining (Class I.) to Chemical and Pharmaceutical products (Class II.) and to Philosophical Instruments (Class X.) are those most interesting to men of science. As space does not permit at this moment any extended abstracts of its contents, we shall take occasion to refer to it again at an early day.

22. *History of the Fishes of Massachusetts;* by DAVID HUMPHREYS STORER.—We have just received a second part of this valuable work, extending from page 91 to 130. It embraces descriptions of species of the Genera Blennius, Gunnellus, Zoarces, Anarrhicas, Lophius, Chironectes, Batrachus, Ctenolabrus, Tautoga, Pimelodus, Cyprinus, Leucosomus, Hypsolepis, Cheilonemus, Argyreus, Catostomus, and Fundulus; and is illustrated with plates 17 to 23, containing figures of the species.

23. *The Principles of Animal and Vegetable Physiology;* a popular Treatise on the Functions and Phenomena of organic life, to which is prefixed a general view of the Great Departments of Human Knowledge; by J. STEVENSON BUSHNAN, M.D., Physician to the Metropolitan Free Hospital, &c. 234 pp. 12mo., with 102 wood-cuts. Philadelphia, 1854. Blanchard & Lea.—There is little of almost everything in this small duodecimo volume.

24. *System der thierischen Morphologie*, von Dr. J. VICTOR CARUS, Prof. der vergleichenden Anatomie in Leipzig. 506 pp. 8vo, with 97 wood-cuts. Leipzig, 1853. Wm. Engelmann.—Dr. Carus, the learned Comparative Anatomist of Leipzig, discusses in a manner both philosophical and profound, the general principles of form and structure in the animal kingdom. The structures of the different simple and complex organs are described with comprehensive views of their relations; next

the processes of growth or developement, and then the particular structures presented by the different types of animal forms. The work closes with chapters on the fundamental relations of type series, and the essential idea of the animal structure.

25. *Atlas von Nord America, nach den neuesten Materialen*, in 18 Blättern mit erläuterndem Texte, herausgegeben von HENRY LANGE. Braunschweig, 1854. G. Westermann.—This Atlas of North America contains 18 plates.—The first is a general map of North America; the next twelve are devoted to the several states of the United States; the 14th to British America; the 15th is an ethnographical chart; the 16th illustrates the distribution of mammalia over North America; the 17th the distribution of plants; the 18th is an enlarged map of San Francisco, the Sacramento and San Joaquin. The maps, although small, are admirably executed, and are remarkable for the fidelity with which they give recent results. The form of the Atlas is a broad quarto, and with each plate there is a leaf of text containing statistical details.

26. *Of the Plurality of Worlds, an Essay.* 279 pp. 18mo. London, J. Parker & Son.—The author of this able essay, whose name does not appear on the title page, endeavors to prove that our own world is the only one in space which is inhabited by rational beings. The argument is conducted with consummate skill and great power, usually with fairness, although sometimes sophistical when direct reasoning was insufficient, and in all parts with ennobling thoughts of man's relations and destiny. With regard to the planets of our system, the evidence is very nearly conclusive that the earth is nearly or quite alone in being tenanted by man. Jupiter, as its density is but 1·1, or little above that of water, is regarded as mostly liquid; Saturn, which is not heavier than cork, as made up mainly of liquid and vapor; and thus all the outer planets are stated to be unfitted from their nature as well as the absence of light and heat, for the higher orders of life. The Earth, the largest of the *solid* planets, is in the temperate zone of the Planetary system, and air, earth and water have here their most equable relations. The argument respecting the fixed stars carries far less, we should say, very little, probability with it. The work has been republished in this country.

27. *More Worlds than one;* by Sir DAVID BREWSTER, is the title of a work written in reply to "The Plurality of Worlds."—The distinguished author rests much on the ground that the making of a world is waste labor unless the surface is afterward stocked with inhabitants; and without a very strict appeal to the analogies furnished by science, he counts much on what Infinite power *may* do in adapting rational creatures to conditions of all possible kinds. The sun, the lava-covered moon, and even Neptune which rolls through space in a perpetual Arctic night, are supposed to have their inhabitants. In these deductions, the work goes to an extreme the opposite of that of "The Plurality of Worlds."

28. *Sixty-seventh Annual Report of the Regents of the University of the State af New York.* 316 pp. 8vo. Albany, 1854.—This Report, like its predecessors, contains much information in the department of Meteorology, besides the various School Reports.

29. *Seventh Annual Report of the Regents of the University of the State of New York, on the Condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto.* 124 pp. 8vo. Albany, 1854.—In addition to lists of recent additions to the State Collections, this volume contains analyses of specimens of salt from different salt mines, domestic and foreign, and a memoir with two plates, on the Serpents of New York, by SPENCER F. BAIRD.

30. *Popular Lectures on Drawing and Design;* by WM. MINNIFIE, Professor of Drawing in the School of Design of the Maryland Institute. 53 pp. 12mo. Baltimore, 1854.—This small pamphlet is made up mostly of popular addresses on some public occasions by the author.

ERASMUS WILSON, F.R.S., Healthy Skin: A Popular Treatise on the Skin and Hair, their preservation and management. 2d American, from the fourth and revised London edition, with illustrations. 292 pp. *Philadelphia*, 1854. Blanchard & Lea. 75 cents.

MÉMOIRES de l'Académie Royale des Sciences de Belgique, Tome 27, 1853; Mémoires couronnés et Mémoires des Savants étrangers, Tome 25, 1851–1853. This last volume contains a memoir of 326 pages and 38 fine plates, on the Fossils of the Secondary Formations of Luxembourg, by M. F. Chaupuis and M. G. Delwaque.

JOURNAL OF THE UNITED STATES AGRICULTURAL SOCIETY. 279 pp. 4to. *Boston*, 1854. Published quarterly.

REPORT OF THE TWENTY-THIRD MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, held at Hull in September, 1853. 212 and 142 pages, 8vo. 1854.

DR. HERMANN SCHILDENER: Der Process der Weltgeschichte als Grundlage der Metaphysik oder Wissen des Wissens ist Wissen der Geschichte. 228 pp. 8vo. Greifswald, 1854. G. A. Koch'sche Verlags-Buchhandlung, Th. Kunike.

PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA. Vol. VII, No. IV.—p. 122. Description of new species of Viviparous marine and freshwater fishes from California; *W. P. Gbibons.*—p. 128. Note on Entophyta; *J. Leidy.*—p. 129. Descriptions of New Fishes collected by Dr. A. L. Heermann, Naturalist attached to the Survey of the Pacific Railroad route, under Lieut. R. S. Williamson, U.S.A.; also (p. 141) of Marine Fishes from San Francisco, collected by Dr. Kennerly, attached to the Survey under Lieut. A. W. Whipple; also (p. 142) of Fishes from the Pacific coast collected by Lieut. W. P. Trowbridge, U.S.A.; *C. Girard.*—p. 156. Synopsis of Extinct Mammalia, the remains of which have been discovered in the Eocene formations of Nebraska; *Dr. Leidy.*—p. 158. Notice of a new genus of Cyprinidæ; *S. F. Baird* and *C. Girard*—Synopsis of the Erotylidæ of the United States; *J. L. LeConte.*—p. 163. Descriptions of new fossil species from the Cretaceous formation of Sage Creek, Nebraska, collected by the North Pacific Railroad Expedition, under Gov. J. J. Stevens; also from the freshwater formation of Nebraska; *J. Evans* and *B. F. Shumard.*

COMPLETE WORKS OF M. ARAGO. *Paris*, chez Hector Bossange.—Two volumes have appeared; the first containing historic eulogies (of Young, Fresnel, Watt, Volta, Fourier, Carnot), and also the history "de ma jeunesse;" the 2d containing Notes on Thunder, the Aurora borealis, Electro-magnetism, Magnetism of rotation discovered by Arago, and some words on Table Turnings.

The following works also are published by H. Bossange:

DE LA BAGUETTE DIVINATOIRE, DU PENDULE DIT EXPLORATEUR, ET DES TABLES TOURNANTES, au point de vue de l'Histoire, de la Critique et de la Méthode expérimentale; par M. Chevreul, Membre de l'Institut. Volume in-8, 1854. Prix: 5 francs.

BOILEAU, Professeur de Mécanique appliquée à l'Ecole d'application de l'Artillerie et du Génie.—Traité de la mesure des eaux courantes, ou Expériences, Observations et Méthodes concernant les lois des vitesses, le jaugeage et l'évaluation de la force mécanique des cours d'eau de toute grandeur; le débit des pertuis des usines, des fortifications et des canaux d'irrigation; et l'action dynamique des courants sur les corps en repos. In-4, avec 7 pl.; 1854. 20 *fr.*

YVON VILLARCEAU, astronome à l'Observatoire de Paris.—Sur l'Établissement des Arches de Pont, envisagé au point dé vue de la plus grande stabilité, et Tables pour faciliter les applications numériques. In-4 avec figures dans le texte et 2 planches; 1854. 12 *fr.*

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